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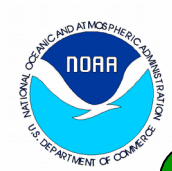
*EMC CCB (Decisional Brief)*  
*March 8, 2016*

# **GDAS/GFS V13.0.0 Upgrades for 2016**

**Presented by:**

**Vijay Tallapragada**  
**Chief, Global Climate and Weather Modeling Branch**

**Based on Work Done by EMC DA, Land Surface, Ensembles, Waves and  
Hurricane Teams and GCWMB**



# GDAS/GFS upgrade

Project Status as of: 3/8/2016

## Scheduling



### Project Information and

#### Leads:

Vijay Tallapragada, EMC, Becky Cosgrove, NCO

#### Scope:

- 1) Upgrade to 4D hybrid EnVar data assimilation
- 2) Produce hourly output out to 120 hrs
- 3) Address high bias in 2m temp. during summer\*

#### Estimated Benefits:

- 4) Generally more skillful forecasts

#### Estimated Resources:

- 5) In the process of determining resources



Milestone (NCEP)	Date	Status
Initial coordination with SPA team	6/1/15	Complete
Submit frozen codes to NCO to setup real-time and retrospective runs	8/21/15 → 8/25 → 10/29/2015	Complete
Pre-CCB Briefing to EMC and OD	1/26/16 → 1/29/2016	Complete
Completion of full retrospective runs	2/1/16 → 2/15/2016	Complete
EMC testing complete/external evaluation complete	10/22/15* → 2/19//2016 → 2/29/2016	Complete
EMC CCB approval	10/23/15 → 2/22/2016 → 3/8/2016	<b>TODAY</b>
Management Briefing	1/15/2016 → 2/25/2016 → 3/10/2016 → 3/17	<b>Scheduled</b>
Final GFS and all downstream codes submitted to NCO	10/27/15 → 1/15/2016 → 1/22/2016 → 1/27/2016 → 2/3/16	Complete
All non-GFS downstream codes submitted to NCO	2/9/2016 → 2/19/2016 → 3/4	<b>Complete</b>
Technical Information Notice Issued	11/30/15 → 2/23/2016 -->4/1	
SPA begins prep work for 30 day test	10/28/15 → 1/19/2016 → 1/23/2016 → 1/28/16 → 2/4/2016	Complete
24-hr parallel production test	3/25/2016	
30-day evaluation begins	12/14/15 → 2/23/2016 → 3/25 → 3/30 → 4/6	
30-day evaluation Ends	1/13/16 → 3/24 → 4/23 → 4/28 → 5/5	
IT testing ends	1/27/16 → 3/31/16 → 4/23 → 4/29	
Final Management Briefing	2/2/16 → 4/18 → 4/29 → 5/4 → 5/11	
Operational Implementation	2/16/16 → 4/19 → 5/3 → 5/10 → 5/17	<b>2</b>



### Issues/Risk

S

#### Issues:

#### Mitigation:



Management Attention Required



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# Table of Contents

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- 1) The GDAS/GFS is being upgraded to 4D-Hybrid En-VAR System
- 2) Land surface improvements to address summertime warm/dry biases in surface fields
- 3) Hourly output fields through 120-hr forecasts
- 4) Evaluation of GDAS/GFS upgrades based on 34 months of retrospective and real-time experiments



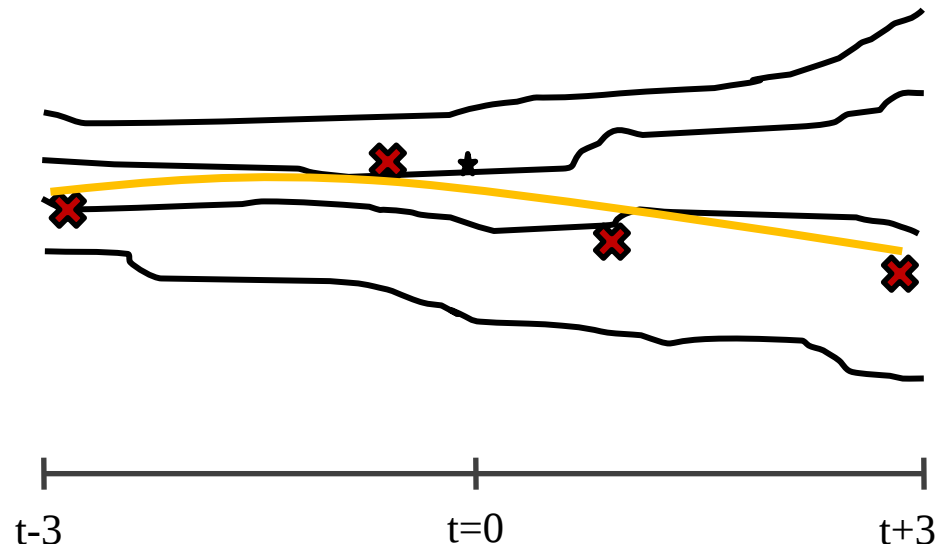
# Next GFS/GDAS in 2016

## The 4D Hybrid En-Var



- 4-D hybrid
- Improved use of satellite radiances
- Improved use of satellite winds and aircraft observations
- Corrections to land surface to reduce summertime warm, dry bias over Great Plains
- CRTM v2.2.1
- NCEP\_POST v7.0
- 3 years of forecasts produced and evaluated

4D Schematic



- The ensemble provides an updated estimate of situation dependent background error every hour as it evolves through the assimilation window. This flow dependent statistical estimate is combined with a fixed estimate.



# DA and Model Changes



## DA Changes: Theoretical and Observational

- 3D to 4D ensemble covariances
- Increase in ensemble contribution from 75% to 87.5%
- Reduction of horizontal localization length scales in the troposphere
- Removal of additive inflation
- Code optimization
- Limit moisture perturbations for improved minimization
- Inclusion of ozone cross-covariances
- Removal of time component for data selection
- 4D thinning of AMVs
- Aircraft temperature bias correction
- All sky microwave radiances
- CRTM upgrade

## Forecast Model and Product Changes

- Convective gravity wave upgrade,
- Tracer adjustment upgrade
- ***Corrections to land surface to reduce summertime warm, dry bias over Great Plains***
- Improved icing probability products and new icing severity product
- ***Hourly output through 120-hr forecast***
- ***5 more levels above 10 hPa***

	Current 3DHybrid	Proposed 4DHybrid
Static / Ensemble Weights	25% static ; 75% ensemble	12.5% static; 87.5% ensemble
Additive Inflation	5%	0%
Tropospheric localization length scales		½ of current 3D Hybrid



# Addressing Summer-time Warm/Dry Biases



GFS showed too little evaporation and too much sensible heat flux, hence Bowen ratio is too high. The factors include:

- Thermal roughness and momentum roughness
- Canopy resistance
- Soil moisture
- .....

**We proposed the following parameter refinements in Q3FY16 GFS:**

- **rsmin for grassland from 45 to 20**
- **rsmin for cropland from 45 to 20**
- **roughness length for cropland from 3.5cm to 12.5cm (used to address too strong surface winds)**



# New Model Upgrade Evaluation Strategy



## GCWMB real time (pr4devb)

period: [2015070100](#) - real time

## GCWMB 2015 summer retrospective (pr4devbs15)

--- **Completed**

period: [2015041500](#) - [2015120100](#) (230 days)

## GCWMB 2013 summer retrospective (pr4devbs13)

--- **Completed**

period: [2013041500](#) - [2013120100](#) (230 days)

## NCO 2013-2014 winter retrospective

(pr4devbw13) --- **Completed**

period: [2013110100](#) - [2014060100](#) (212 days)

## NCO 2014 summer retrospective

(pr4devbs14) --- **Completed**

period: [2014050100](#) - [2014120100](#) (214 days)

## GCWMB 2014-2015 winter retrospective

(pr4devbw14) --- **Completed**

period: [2014110100](#) - [2015070100](#) (242 days)

## GCWMB Special retrospective for H. Sandy

period: [2012101700](#) - [201213100](#) (15 days) ---

**Completed**

- Involve field in real-time and retrospective evaluation of science upgrades --- **Completed**
- Identify case studies and provide data for extended evaluation period beyond last 30-day parallel --- **Completed**
- **NCO 30-day parallel is only for IT evaluation**

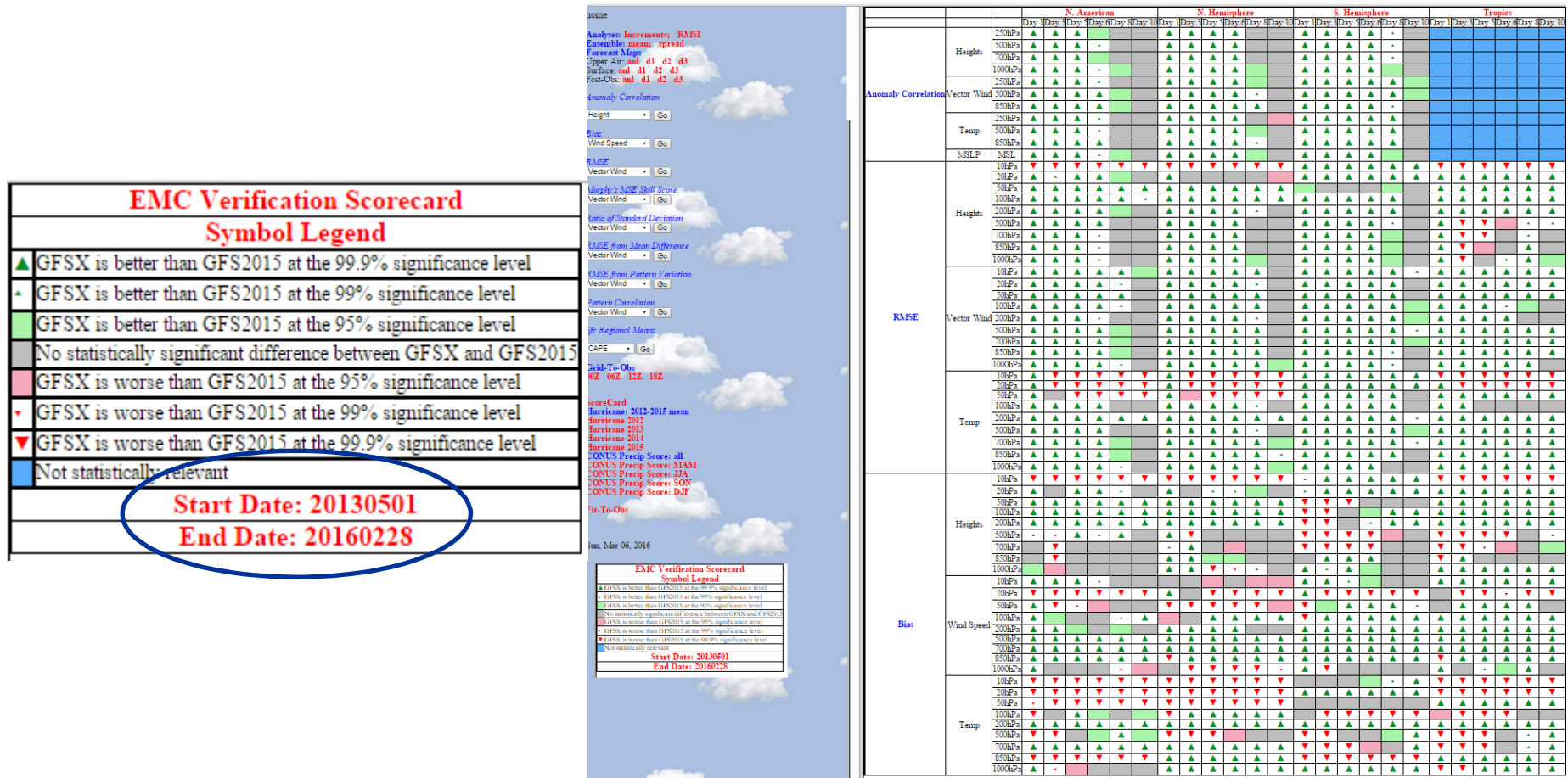


# Comprehensive Evaluation from EMC

## Part 1



- Retrospectives—Standard verification page against own analyses, GFS2015 vs. GFS2016: <http://www.emc.ncep.noaa.gov/gmb/wx24fy/vsdb/gfs2016/>





# Comprehensive Evaluation from EMC

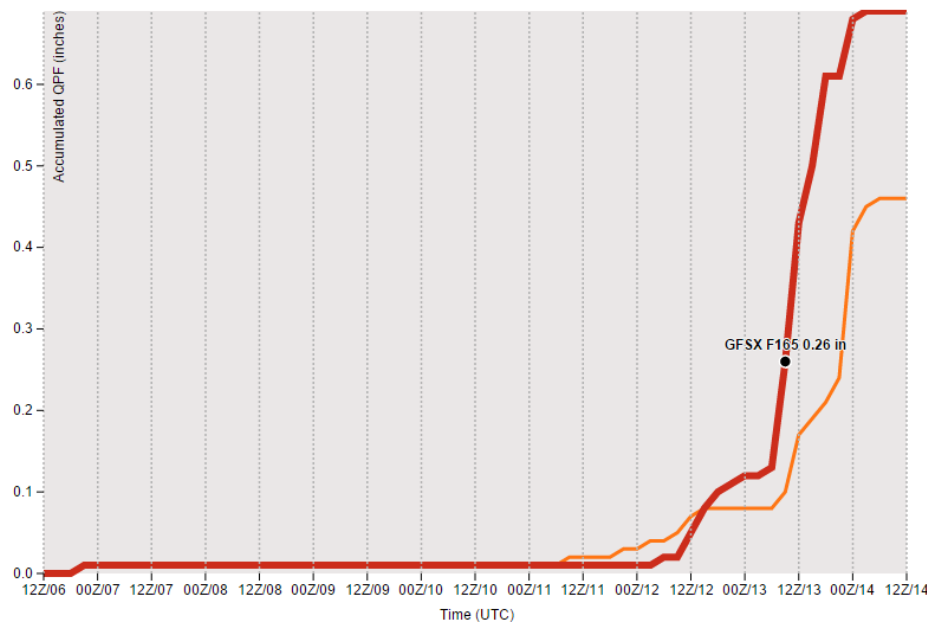
## Part 2



- Real time plots of near surface variables at representative stations:

[http://www.emc.ncep.noaa.gov/gc\\_wmb/parthab/Plume\\_test/GFSx/EMCGEF\\_Splumes.html](http://www.emc.ncep.noaa.gov/gc_wmb/parthab/Plume_test/GFSx/EMCGEF_Splumes.html)

EMC's GFS plumes for: KIAD  
12 UTC 06 March 2016 cycle



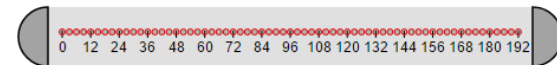
y min

y max

Set y axis

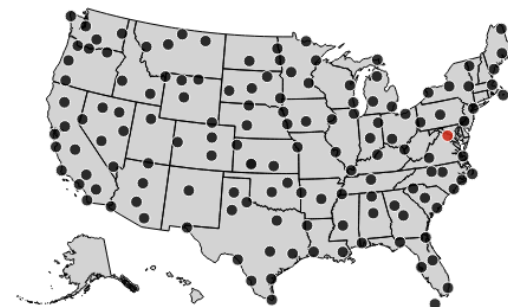
Reset y axis

Choose forecast hours to span by adjusting gray box



Click map to zoom/recenter

Reset zoom



Variable: QPF  
QPF  
3-h QPF  
2-m T  
2-m Td  
10-m wind  
850-hPa T  
PW  
CAPE  
Shear

Cycle: 2016030612

About the plumes: Data for each station is interpolated from a 0.25-degree grid for both the GFS T1534 operational (Orange line); and GFSx T1534 (Blue line). This site is not operational; therefore, data may be missing occasionally.



# Comprehensive Evaluation from EMC

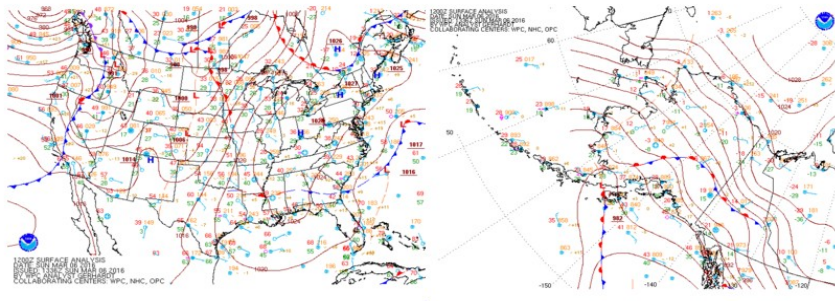
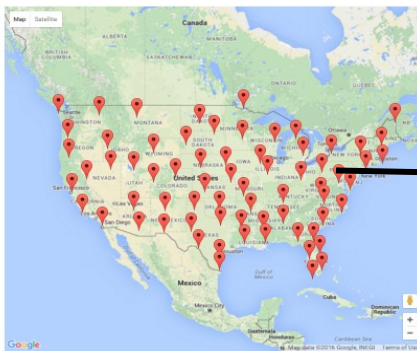
## Part 3



- GFS Soundings available on case by case basis, [real-time page](http://www.emc.ncep.noaa.gov/gc_wmb/tdorian/meg/index.html) for selected cities:

[http://www.emc.ncep.noaa.gov/gc\\_wmb/tdorian/meg/index.html](http://www.emc.ncep.noaa.gov/gc_wmb/tdorian/meg/index.html)

Daily Sounding Verification for the GFS and the GFSX  
(12-h forecasts valid at 12Z)  
*Soundings update everyday shortly at 15UTC*  
*\* Work in Progress \**  
*\* Will add many more stations in the near future \**

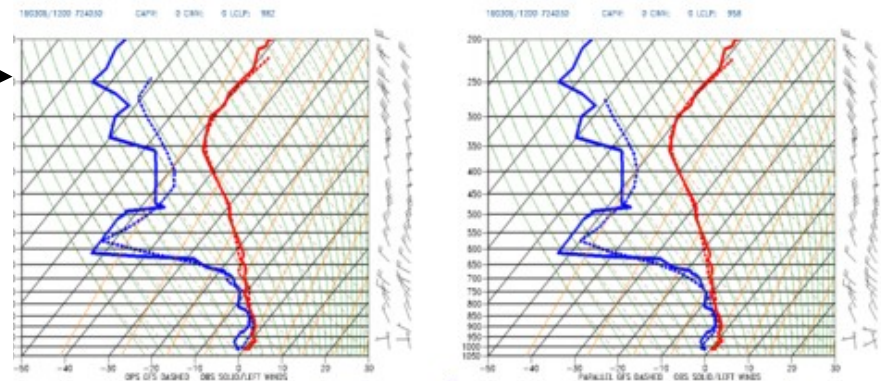


12-h VERIFICATION  
INITIALIZED AT 00Z  
VALID AT 12Z

WASHINGTON/DULLES

GFS

GFSX



Dashed = Forecast  
Solid = Observations  
Left winds = Observations

Please contact [tracey.dorian@noaa.gov](mailto:tracey.dorian@noaa.gov) for any questions (or for archived sounding requests)

\* Archived soundings go back to January 11, 2016 for most stations



# Comprehensive evaluation Part 4 (Centers, Regions & case studies)



Case Studies	Case Studies
<a href="#">MEG review of case studies proposed by WPC, Western Region</a>	<a href="#">A case study for Dec. 5-6, 2013 requested by Southern Region</a>
<a href="#">MEG review of additional case studies</a>	<a href="#">Blizzard of January 22-23, 2016</a>
<a href="#">Presentation to WPC on case studies</a>	<a href="#">Precipitation cases for WPC</a>
<a href="#">Western Region/Central region case study</a>	<a href="#">Height field evaluation for WPC</a>
<a href="#">Central Region case study, Alaska case study and Southern Region case study</a>	<a href="#">Operational and experimental GFS forecasts for Alaska (extratropical transition, Alaska region)</a>
Case studies for Central Region <a href="#">March 23, 2015</a> ; <a href="#">April 2, 2015</a> ; <a href="#">June 4-5, 2015</a> ; <a href="#">July 6, 2015</a>	<b>MODE evaluations of new GFS: <a href="#">Precip</a>; <a href="#">Total Winds</a>; <a href="#">Zonal Winds</a>; <a href="#">Meridional Winds</a>; and <a href="#">CAPE</a></b>
<a href="#">A case study of the Nov. 16-17, 2015 tornado outbreak</a>	<a href="#">WPC documentation of dry bias over the southeastern U.S.</a>
<b>Evaluation from EMC Teams: <a href="#">HWRP</a>; <a href="#">Ensemble</a>; <a href="#">Wave</a></b>	<a href="#">Case study of GFS and GFSX cold bias over snow pack</a>
<a href="#">Hurricane Joaquin and South Carolina flooding</a>	<a href="#">Verification from Data Assimilation perspective</a>
Warm dry bias over Great Plains in summer: <a href="#">Here</a> and <a href="#">Here</a> ; Case study: <a href="#">Here</a>	MEG presentations reviewing the new GFS <a href="#">Nov. 12</a> ; <a href="#">Nov. 19</a> ; <a href="#">Dec. 17</a> ; and <a href="#">Feb. 11</a>
<a href="#">Extratropical storm tracks</a>	Evaluation from the Centers: <a href="#">CPC</a> ; <a href="#">NHC</a> ; <a href="#">SPC</a> ; <a href="#">OPC</a> ;
<a href="#">Comparison of systematic errors in the GFS and GFSX</a>	<a href="#">Forecast tracks for Sandy</a>



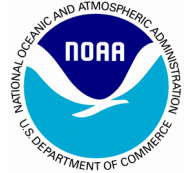
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# Evaluation of Q3FY16 GDAS/GFS Upgrade:

## EMC Perspective



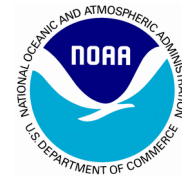
# Summary of various evaluation metrics



<b>Evaluation</b>	<b>Remarks</b>
<b>Analysis increments</b>	<b><i>2016 GFS much smaller increments --analysis and first guess in better agreement</i></b>
<b>Score card</b>	<b><i>Significant improvements in many aspects of the evaluation metrics. Upper Stratospheric biases showed degradation.</i></b>
<b>500 hPa ACC</b>	<b><i>0.004 gain in NH; 0.007 gain in SH; statistically significant improvements through 168 hrs</i></b>
<b>Surface heights</b>	<b><i>Significant improvements through 192 hrs in both hemispheres</i></b>
<b>Winds</b>	<b><i>Significant reduction of RMSE through 240 hrs in both hemispheres and global tropics</i></b>
<b>Temperature RMSE</b>	<b><i>Big improvements in Southern Hemisphere. Upper troposphere/ Stratosphere in Northern Hemisphere has increased RMSE. 850 hPa temperatures significantly improved.</i></b>
<b>Temperature fit to obs</b>	<b><i>Better fit to obs except in the upper stratosphere. Significant reduction of RMSE in NH, SH and global tropics.</i></b>



# Summary of various evaluation metrics



<b>Evaluation</b>	<b>Remarks</b>
<b>Vector wind RMSE</b>	<i>Better fit to obs, significant reduction of RMSE in NH, SH at 850 and 200 hPa. No significant change in global tropics.</i>
<b>CONUS Precip</b>	<i>Rain/no rain (Threshold of 0.2 mm/day) worse in GFSX Thresholds of 2 to 25 mm/day significantly improved</i>
<b>CONUS Near Surface Fields</b>	<i>Significant improvements in T2m, Td2m, Latent Heat, CAPE and Surface Winds</i>
<b>Hurricane Tracks and cyclogenesis</b>	<i>Positive improvements in both NATL and EPAC, for tracks and intensity. Significant improvement in tropical cyclogenesis forecasts.</i>
<b>TAFB</b>	<i>GFSP seemed to have an advantage at longer lead times for gap wind events</i>
<b>Extra tropical cyclone tracks</b>	<i>7 out 10 times, errors in GFSX are smaller than in GFSO in winter. During summer months, the errors are always smaller in parallel GFS.</i>
<b>OPC Evaluation</b>	<i>Track errors for winter season are a slight improvement shorter term and no significant improvement medium range</i>



# Summary of various evaluation metrics

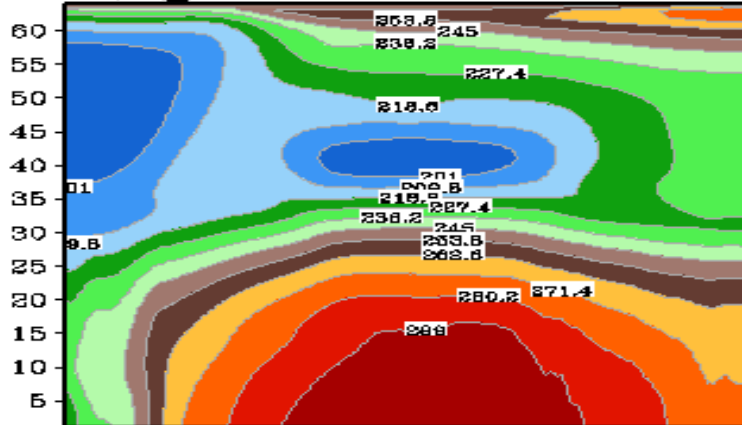


<b>Evaluation</b>	<b>Remarks</b>
<b>MODE verification</b>	<b><i><u>Jet Streams</u>: GFSX generally looks “better” and closer to the ECMWF; <u>QPF</u>: GFSX has higher MMI (Median of Maximum Interest) values for all forecast hours except at 60-h; <u>CAPE</u>: GFSX somewhat better than GFS. Both underestimate compared to RAP analysis</i></b>
<b>Case studies from Field</b>	<b><i>GFSX better in 6 cases out of 9, operational GFS better in 3 (subjective evaluation)</i></b>
<b>Typhoon Astani</b>	<b><i>GFSX better in 7 verification times, operational GFS in 3 verification times.</i></b>
<b>WPC Case studies</b>	<b><i>Of the 6 precipitation case studies (36 hour forecasts), the GFSX did better for 3 cases, the operational GFS was better for 1 case, and both models tied for 2 cases.</i></b>
<b>Ensemble Team verification</b>	<b><i>2014 Winter: Good for short forecast (days 1-3); Slight degradation (days 5-10). 2014 Summer: Good for all lead time (out to day 12)</i></b>
<b>HWRF Team</b>	<b><i>New GFS shows improved track and intensity forecasts in the N. Atlantic and neutral impact in the E. Pacific</i></b>

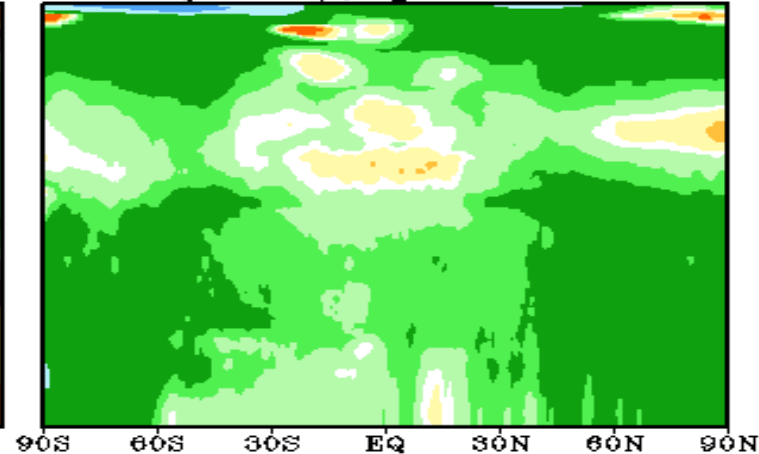
# 2016 GFS much smaller increments --analysis and first guess in better agreement

RMS of GDAS Analysis Increments, Temp (K)  
[00 06 12 18] Cycles, 01Jun2016 ~ 30Jun2016

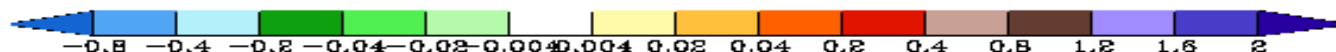
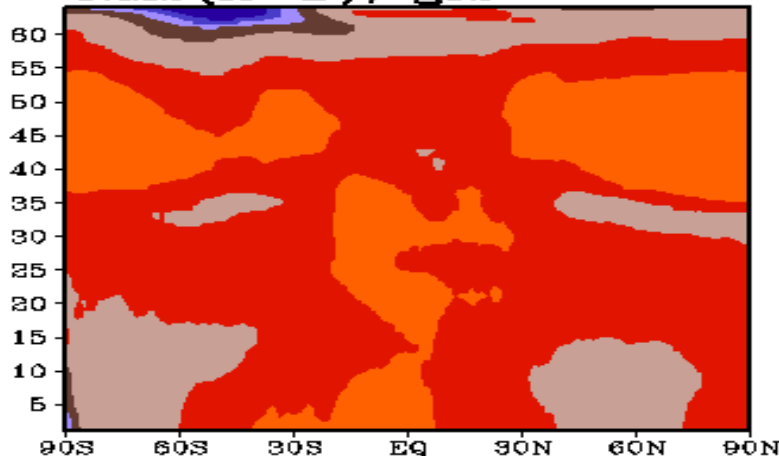
A, gfs



RMS(A-B), pr4devbs15-gf:



RMS(A-B), gfs





# Fit to Obs Evaluation



Red: Worse

Green: Better

## Temperature

	<i>Analysis fit to radiosondes</i>	<i>Forecast fit to radiosondes</i>
<b>NH</b>	1000-400, 150-20 hPa 200-300 hPa	30, 20 hPa 1000-100 hPa
<b>SH</b>	925-700, 100-20 hPa 400-200 hPa	30 hPa 1000-100 hPa
<b>Tropics</b>	975-100, 150-20 hPa 250, 300 hPa	850-400, 200-100, 20 hPa 300, 250, 70, 50 hPa

## Winds

	<i>Analysis fit to radiosondes</i>	<i>Forecast fit to radiosondes</i>
<b>NH</b>	1000-500, 150-20 hPa 300, 250hPa	30, 20 hPa 1000-70 hPa
<b>SH</b>	1000-400, 150-20 hPa 250 hPa	1000-70, 20 hPa
<b>Tropics</b>	1000-400; 150-50 hPa 250, 300 hPa	1000, 850-250, 150-50 hPa



# ***Score Card for Verification of Q3FY16***

## ***34 months of retrospectives (2013-2016)***



### **EMC Verification Scorecard**

#### **Symbol Legend**

- ▲ GFSX is better than GFS2015 at the 99.9% significance level
- ▲ GFSX is better than GFS2015 at the 99% significance level
- GFSX is better than GFS2015 at the 95% significance level
- No statistically significant difference between GFSX and GFS2015
- GFSX is worse than GFS2015 at the 95% significance level
- ▼ GFSX is worse than GFS2015 at the 99% significance level
- ▼ GFSX is worse than GFS2015 at the 99.9% significance level
- Not statistically relevant

**Start Date: 20130501**

**End Date: 20160228**

***34 months***  
***Verified against own analyses***



# Anomaly Correlations & RMSE

## GFSX vs. GFS



			N. American							N. Hemisphere						S. Hemisphere						Tropics						
			Day 1	Day 3	Day 5	Day 6	Day 8	Day 10	Day 1	Day 3	Day 5	Day 6	Day 8	Day 10	Day 1	Day 3	Day 5	Day 6	Day 8	Day 10	Day 1	Day 3	Day 5	Day 6	Day 8	Day 10		
Anomaly Correlation	Heights	250hPa	▲	▲	▲	■	■	■	▲	▲	▲	▲	■	■	▲	▲	▲	▲	▲	■	■	■	■	■	■	■	■	
		500hPa	▲	▲	▲	▲	■	■	▲	▲	▲	▲	■	■	▲	▲	▲	▲	▲	■	■	■	■	■	■	■	■	
		700hPa	▲	▲	▲	■	■	■	▲	▲	▲	▲	■	■	▲	▲	▲	▲	▲	■	■	■	■	■	■	■	■	
		1000hPa	▲	▲	▲	▲	■	■	▲	▲	▲	▲	■	■	▲	▲	▲	▲	▲	■	■	■	■	■	■	■	■	
	Vector Wind	250hPa	▲	▲	▲	▲	■	■	▲	▲	▲	▲	■	■	▲	▲	▲	▲	▲	▲	■	■	■	■	■	■	■	
		500hPa	▲	▲	▲	▲	■	■	▲	▲	▲	▲	▲	■	■	▲	▲	▲	▲	▲	■	■	■	■	■	■	■	
		850hPa	▲	▲	▲	▲	■	■	▲	▲	▲	▲	▲	■	■	▲	▲	▲	▲	▲	■	■	■	■	■	■	■	
	Temp	250hPa	▲	▲	▲	▲	■	■	■	▲	▲	▲	▲	■	■	■	▲	▲	▲	▲	▲	■	■	■	■	■	■	
		500hPa	▲	▲	▲	▲	■	■	■	▲	▲	▲	▲	■	■	■	▲	▲	▲	▲	▲	■	■	■	■	■	■	
		850hPa	▲	▲	▲	▲	■	■	■	▲	▲	▲	▲	▲	■	■	■	▲	▲	▲	▲	■	■	■	■	■	■	
MSLP	MSL	▲	▲	▲	▲	■	■	▲	▲	▲	▲	■	■	▲	▲	▲	▲	▲	■	■	■	■	■	■	■	■		
RMSE	Heights	10hPa	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▲	▲	▲	▲	▲	▲	▼	▼	▼	▼	▼	▼	▼	
		20hPa	▲	▲	▲	▲	■	■	▲	■	■	■	■	■	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	
		50hPa	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	■	■	■	■	■	▲	▲	▲	▲	▲	▲	▲	
		100hPa	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	
		200hPa	▲	▲	▲	▲	■	■	■	▲	▲	▲	▲	■	■	▲	▲	▲	▲	▲	▲	▲	▼	▼	■	▲	▲	
		500hPa	▲	▲	▲	▲	■	■	■	▲	▲	▲	▲	■	■	■	▲	▲	▲	▲	▲	▲	▼	▼	■	▲	▲	
		700hPa	▲	▲	▲	▲	■	■	■	▲	▲	▲	▲	■	■	■	▲	▲	▲	▲	■	▲	▼	▼	■	▲	▲	
		850hPa	▲	▲	▲	▲	■	■	■	▲	▲	▲	▲	■	■	■	▲	▲	▲	▲	■	▲	▼	■	■	▲	▲	
	Vector Wind	10hPa	▲	▲	▲	▲	▲	■	■	▲	▲	▲	▲	▲	■	■	■	■	■	■	▲	▲	▲	▲	▲	▲	▲	
		20hPa	▲	▲	▲	▲	▲	▲	■	▲	▲	▲	▲	▲	■	■	■	■	■	■	▲	▲	▲	▲	▲	▲	▲	
		50hPa	▲	▲	▲	▲	▲	■	■	▲	▲	▲	▲	▲	■	■	■	■	■	■	▲	▲	▲	▲	▲	▲	▲	
		100hPa	▲	▲	▲	▲	▲	■	■	▲	▲	▲	▲	▲	■	■	■	■	■	■	▲	▲	▲	▲	▲	▲	▲	
		200hPa	▲	▲	▲	▲	■	■	■	▲	▲	▲	▲	▲	■	■	■	■	■	■	▲	▲	▲	▲	■	■	■	
		500hPa	▲	▲	▲	▲	■	■	■	▲	▲	▲	▲	▲	■	■	■	■	■	■	▲	▲	▲	▲	▲	▲	▲	
		700hPa	▲	▲	▲	▲	■	■	■	▲	▲	▲	▲	▲	■	■	■	■	■	■	▲	▲	▲	▲	▲	▲	▲	
		850hPa	▲	▲	▲	▲	■	■	■	▲	▲	▲	▲	▲	■	■	■	■	■	■	▲	▲	▲	▲	▲	▲	▲	
	Temp	10hPa	▲	▼	▼	▼	▼	▼	▼	▲	▼	▼	▼	▼	▼	▲	▲	▲	▲	▲	▲	▼	▼	▼	▼	▼	▼	▼
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# Biases

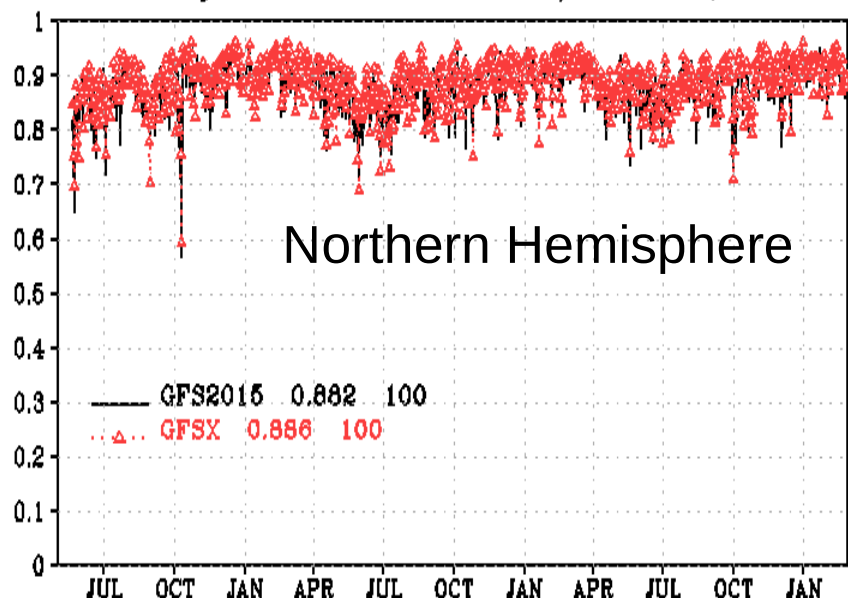
## GFSX vs. GFS



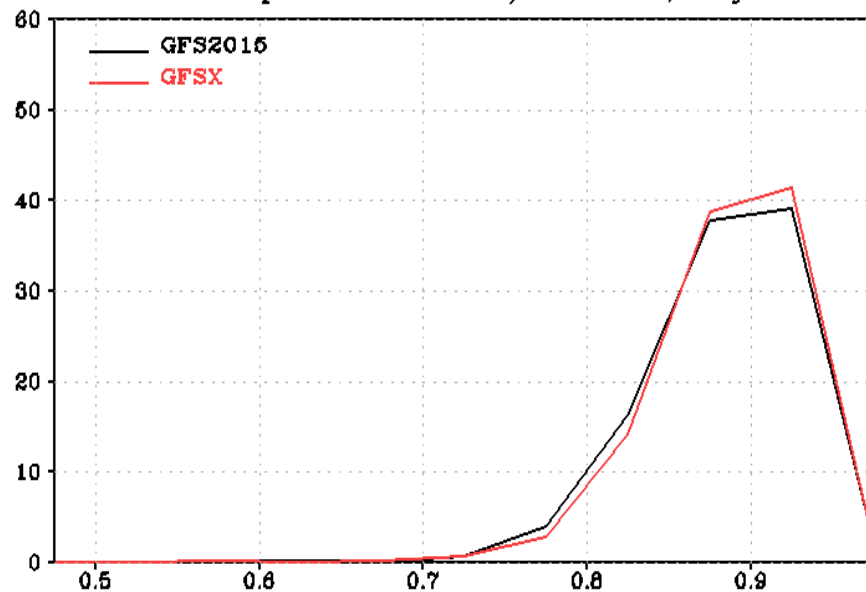
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		Day 1	Day 3	Day 5	Day 6	Day 8	Day 10	Day 1	Day 3	Day 5	Day 6	Day 8	Day 10	Day 1	Day 3	Day 5	Day 6	Day 8	Day 10	Day 1	Day 3	Day 5	Day 6	Day 8	Day 10
Bias	Heights	10hPa	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼
		20hPa	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
		50hPa	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼	▲	▲	▲	▲	▲	▲	▲	▲	▲
		100hPa	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
		200hPa	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
		500hPa	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼	▲	▲	▲	▲	▲	▲	▲	▲	▲
		700hPa	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▼	▼	▲	▲	▲	▲	▲	▲	▲	▲	▲
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	Wind Speed	1000hPa	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
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Significant improvements in many aspects of the evaluation metrics.  
*Upper Stratospheric biases showed degradation.*

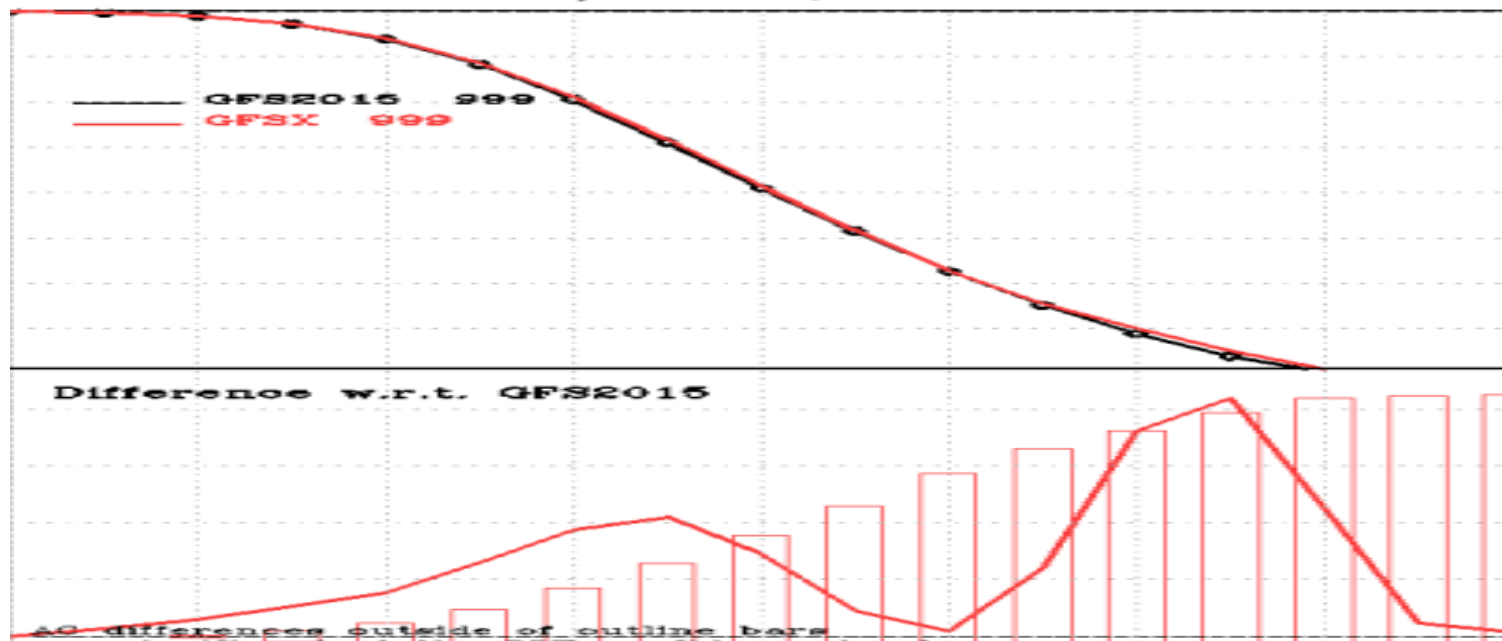
Anomaly Correl: HGT P500 G2/NHX 00Z, fh120



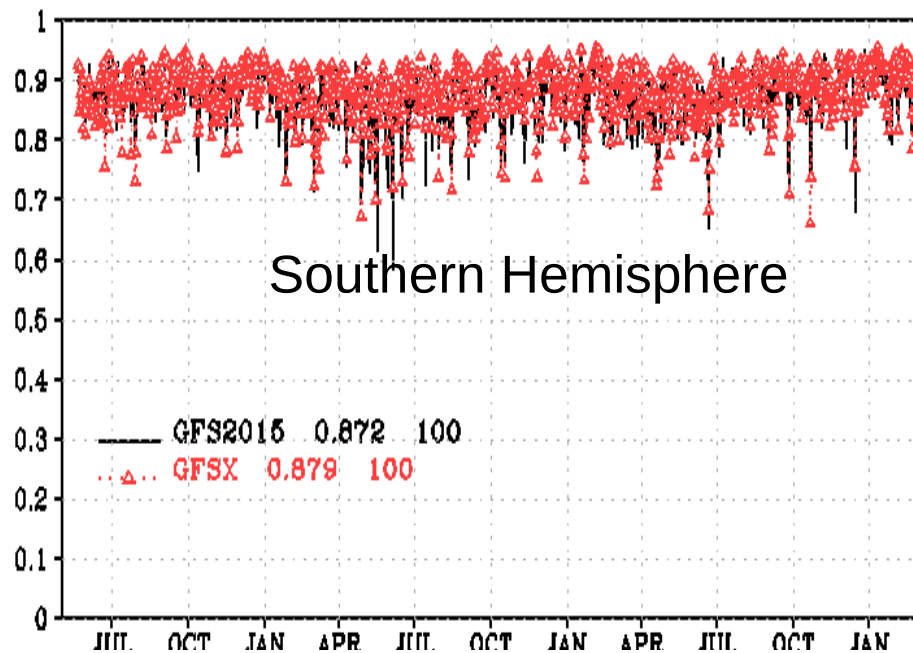
AC Freq: HGT P500 G2/NHX 00Z, Day 5



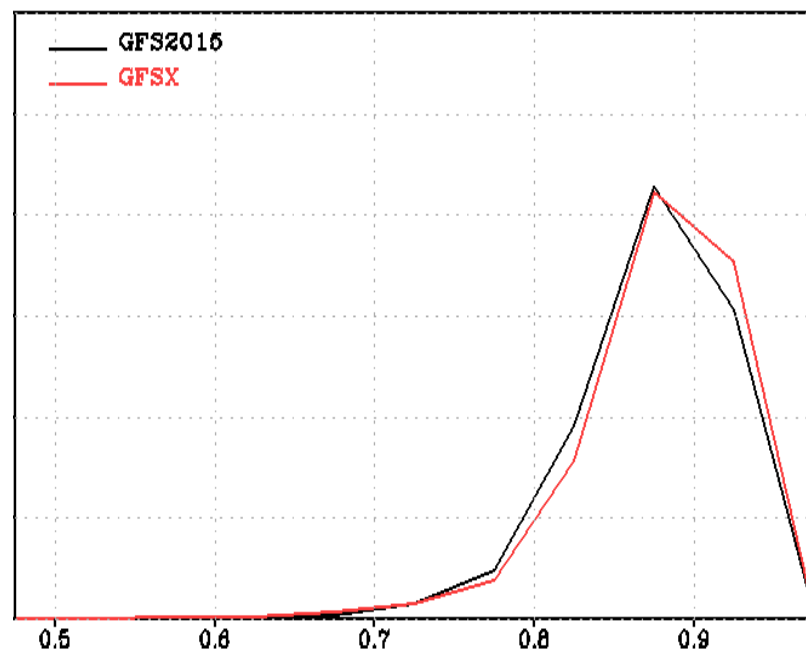
AC: HGT P500 G2/NHX 00Z, 20130501-20160228



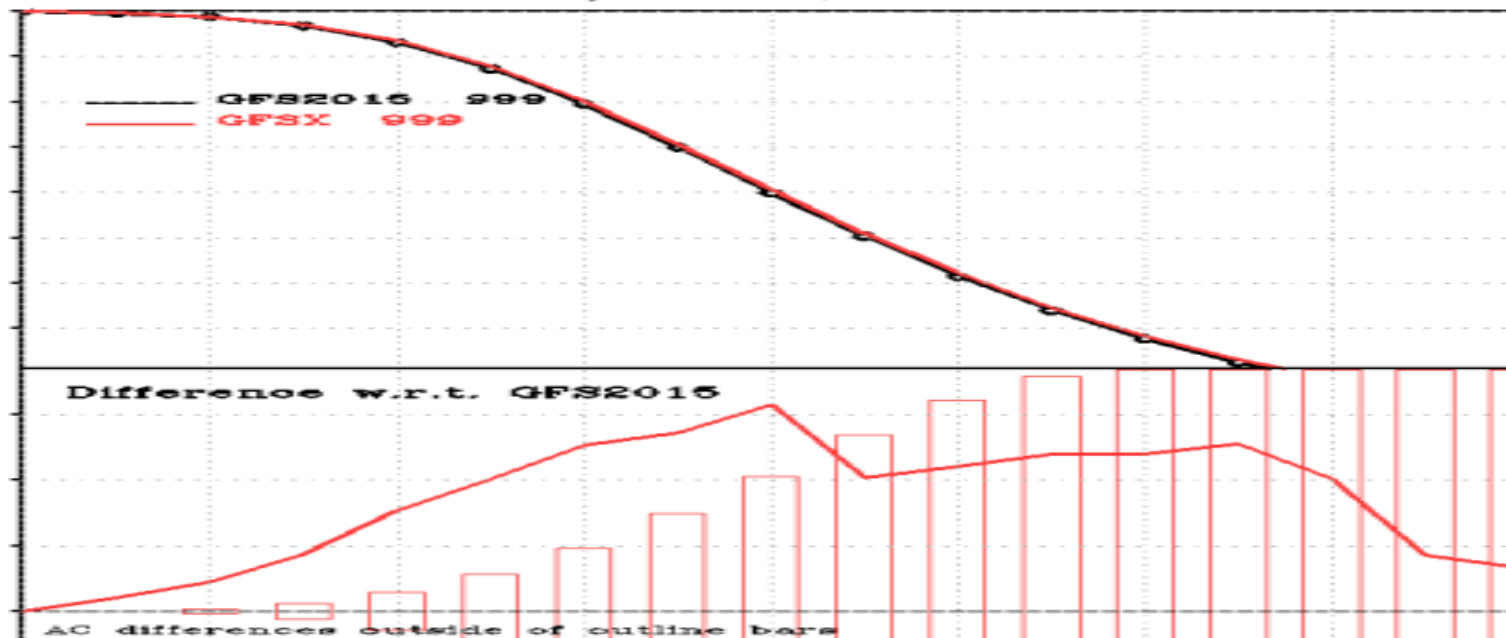
Anomaly Correl: HGT P500 G2/SHX 00Z, fh120



AC Freq: HGT P500 G2/SHX 00Z, Day 5



AC: HGT P500 G2/SHX 00Z, 20130501-20160228

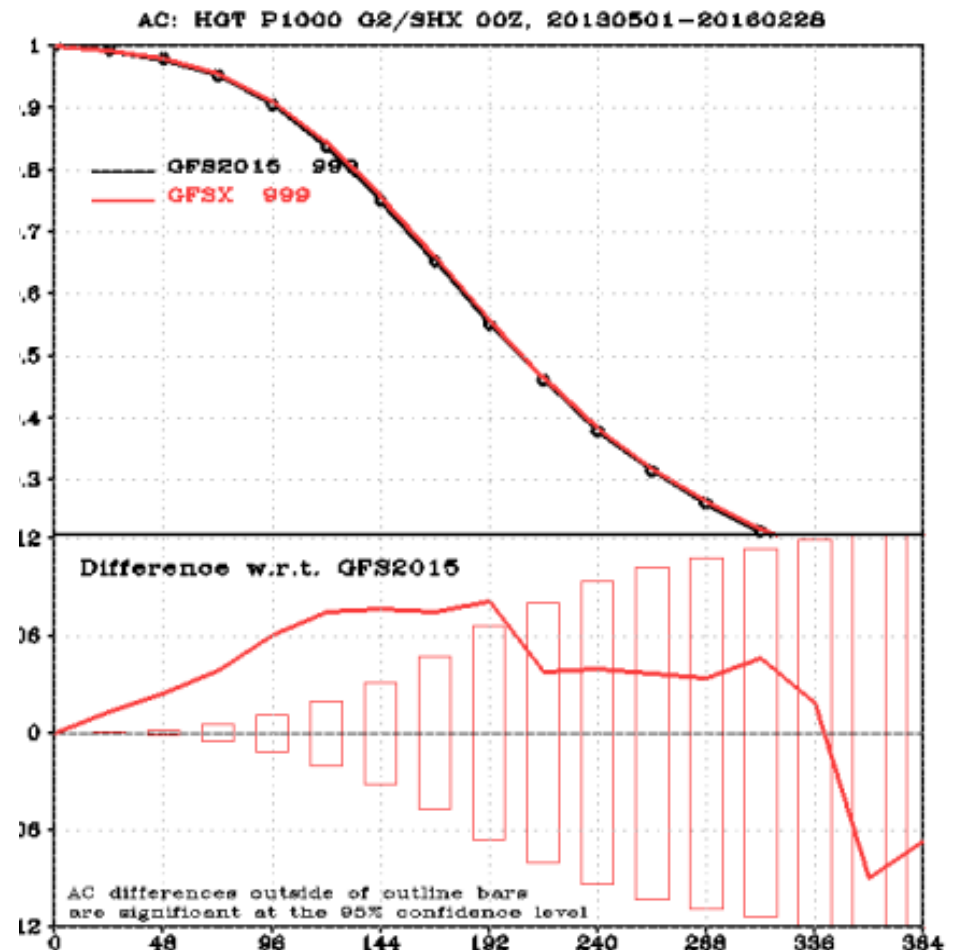
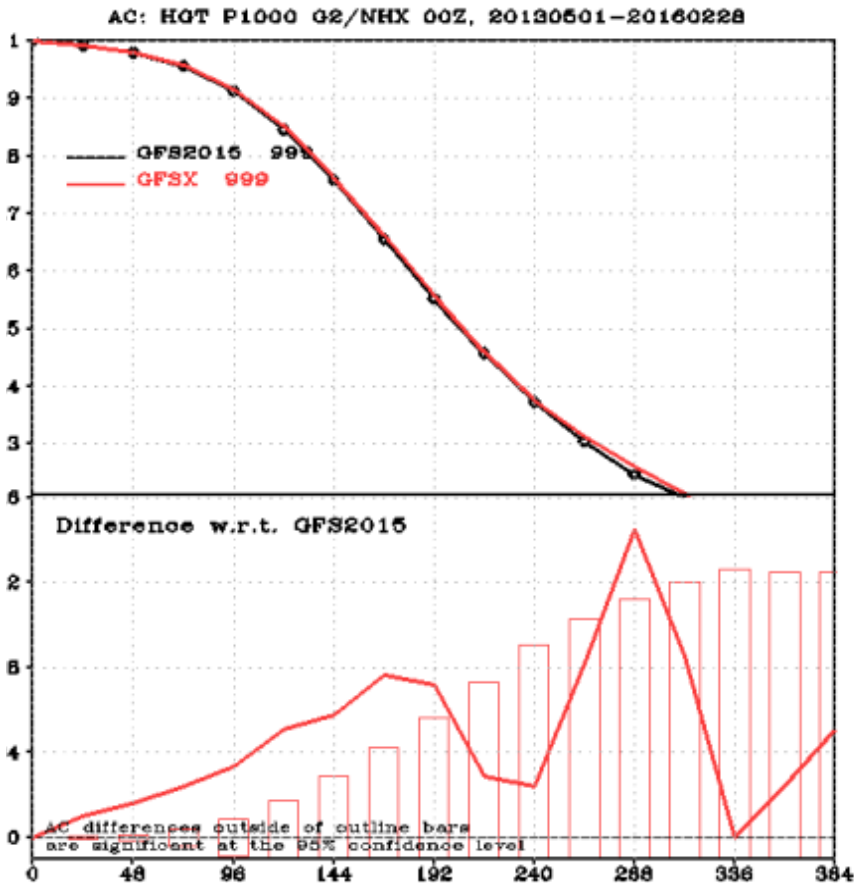




# Surface heights



## Northern Hemisphere



## Southern Hemisphere



# Assessment of impact of LSM changes

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- 2m T cooler, bias is worse over the Northern Plains and Northeast, Better over southern plains and southeast
- RMS error improved over northern and southern plains, Southeast and Alaska, worse over northwest
- 10 m winds decreased, RMS error improved
- **The land surface parameter refinements have significantly reduced the warm/dry biases in the summer**
- **The change has little impact in the winter. However there are some degradations in the spring/fall. Also it is worst in 00Z (sunset). Some of them will be addressed in the next GFS physics implementation.**

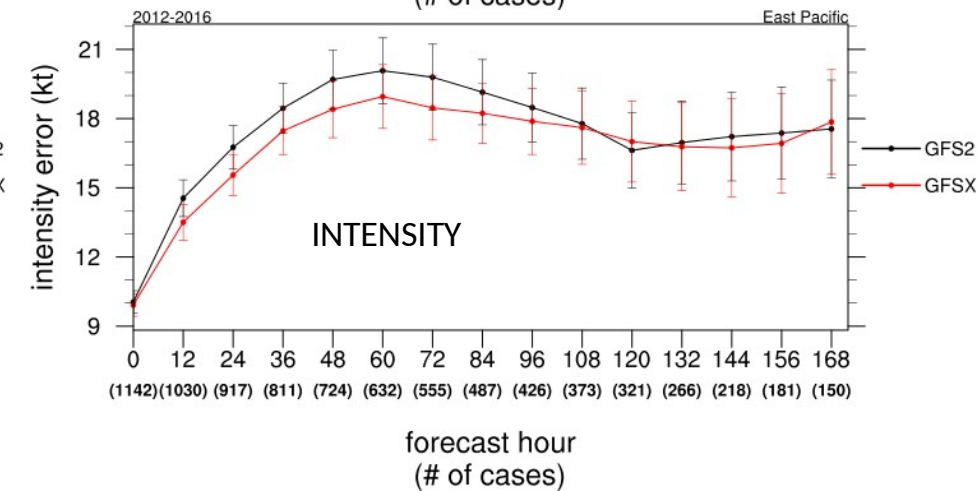
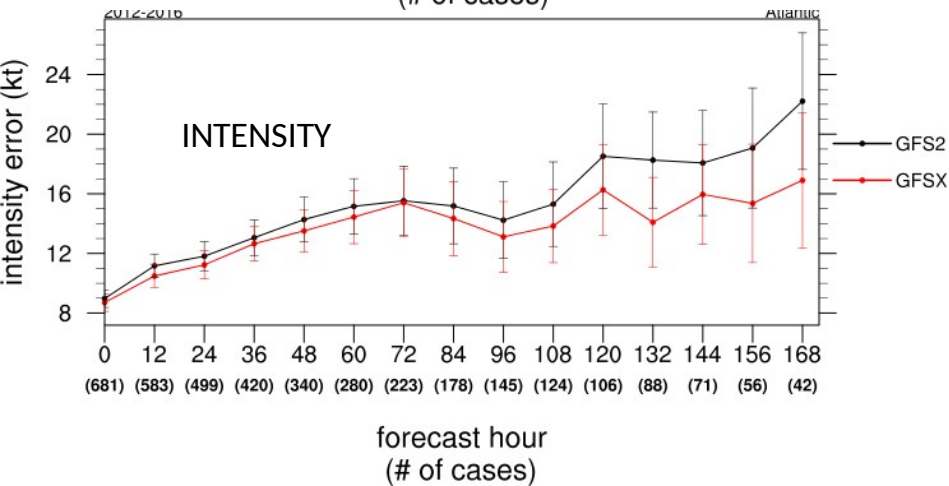
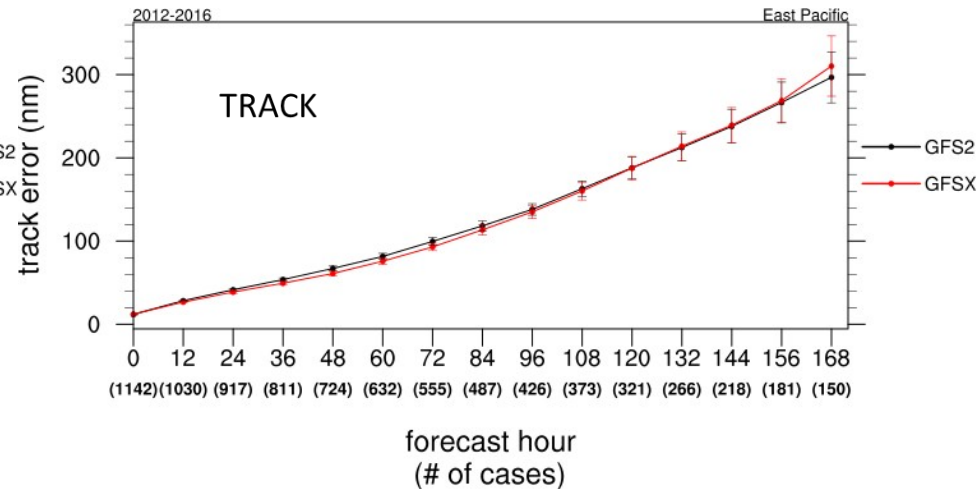
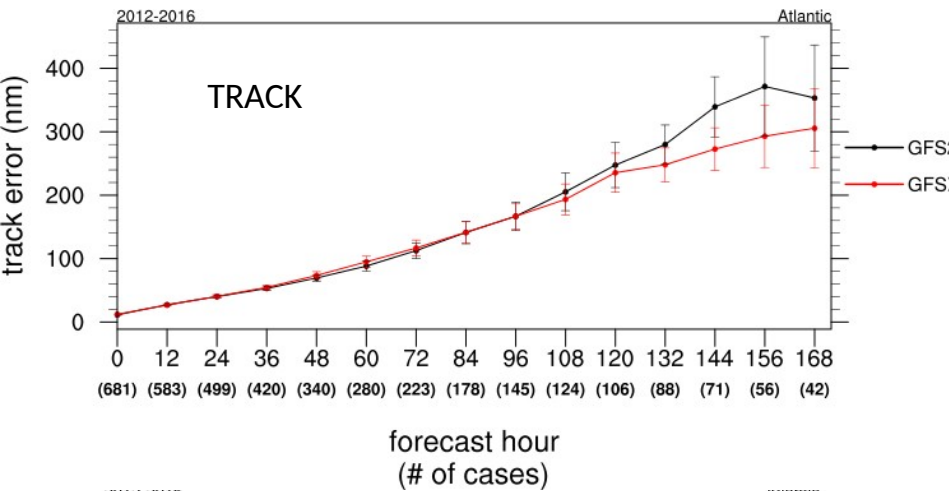
# Impact on Hurricanes: NHC Evaluation

2012-2016

Atlantic

Track/Intensity Error

East Pacific



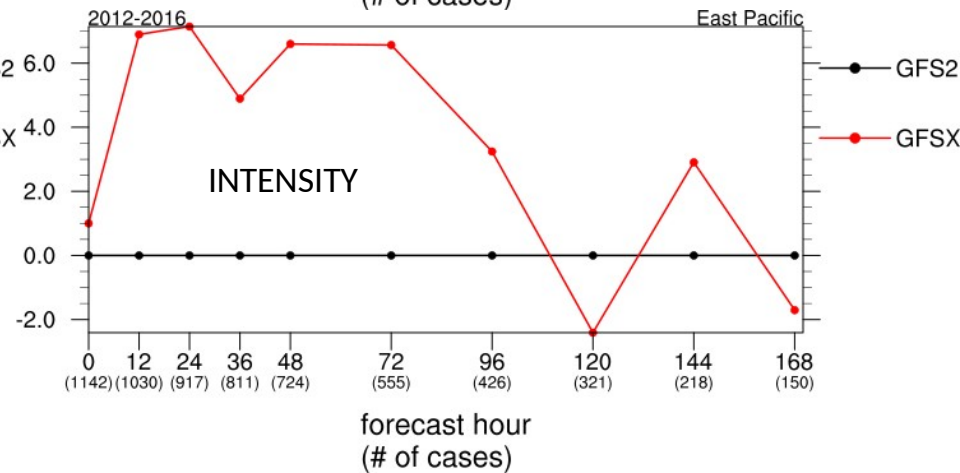
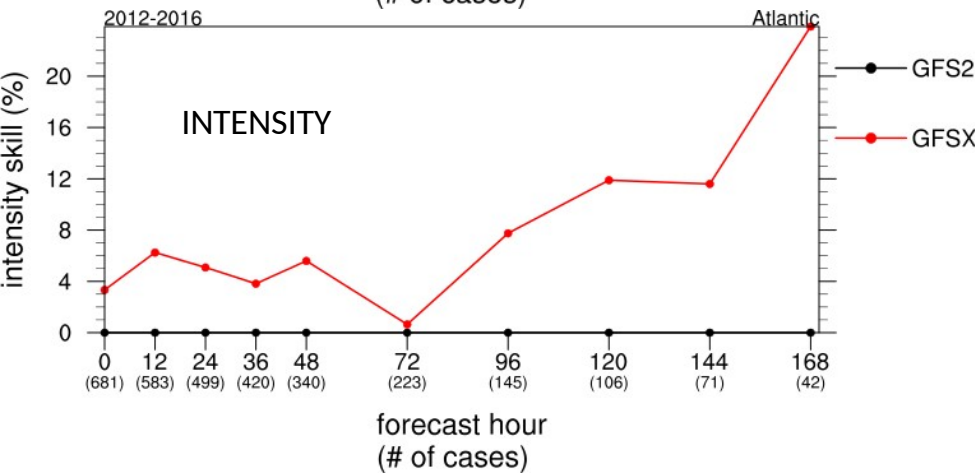
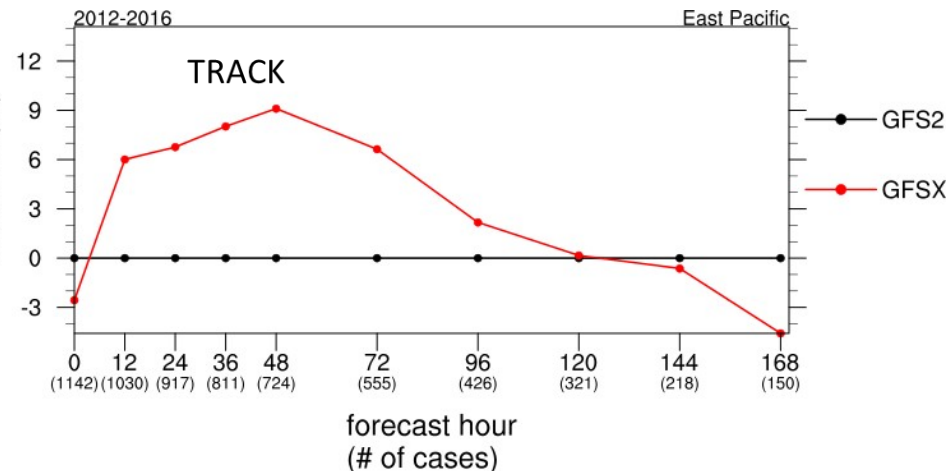
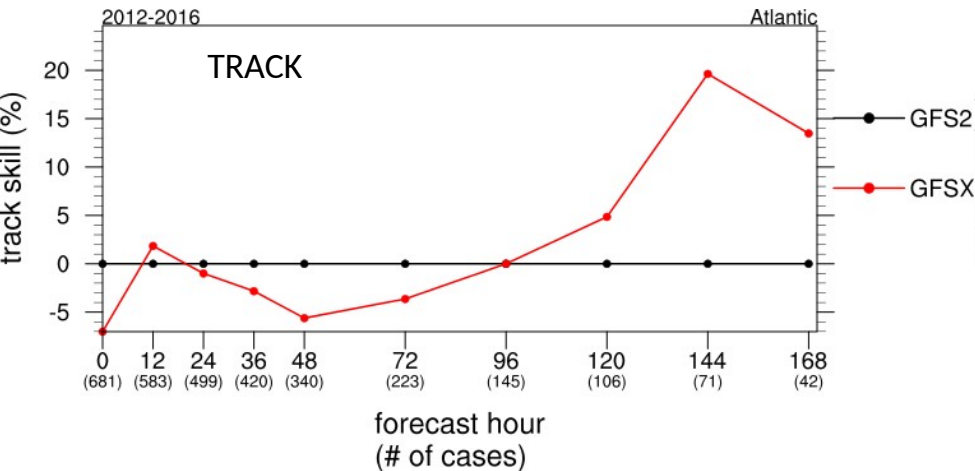
# Impact on Hurricanes: NHC Evaluation

2012-2016

Atlantic

Track/Intensity Skill  
(with respect to GFS2)

East Pacific

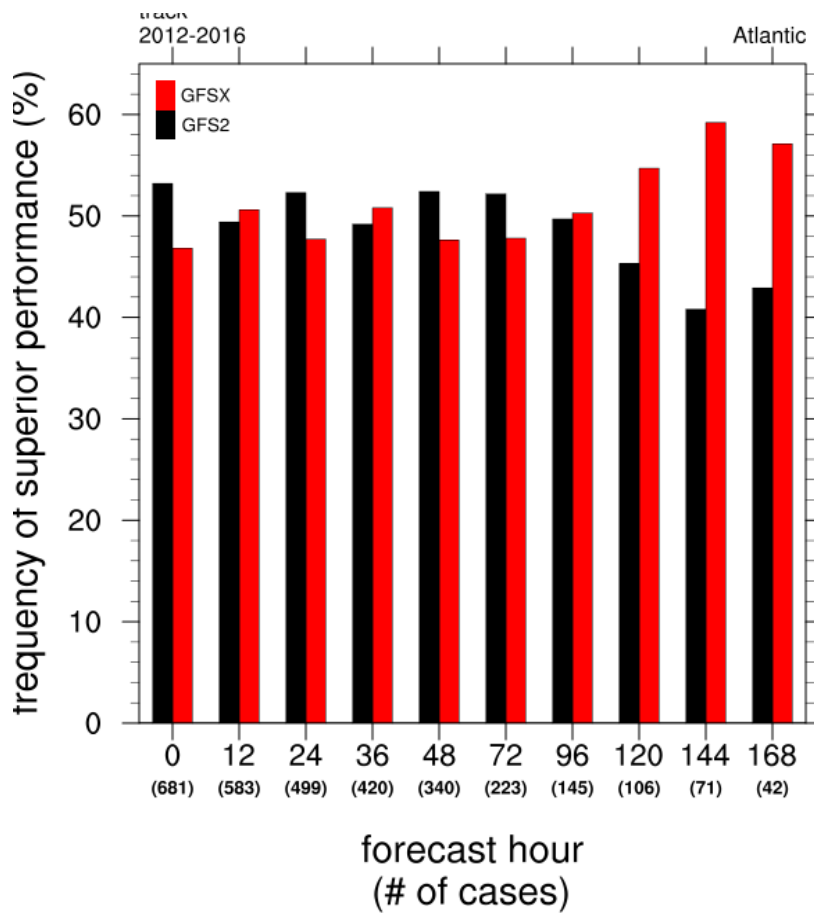


# Impact on Hurricanes: NHC Evaluation

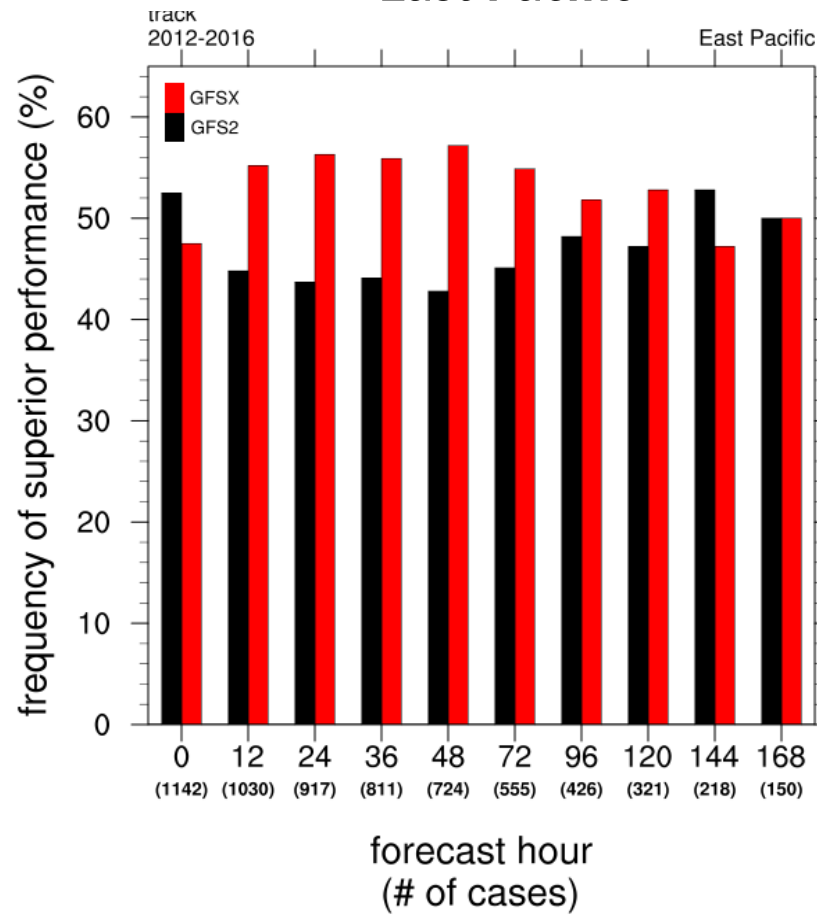
2012-2016

Frequency of Superior Performance - Track

## Atlantic



## East Pacific

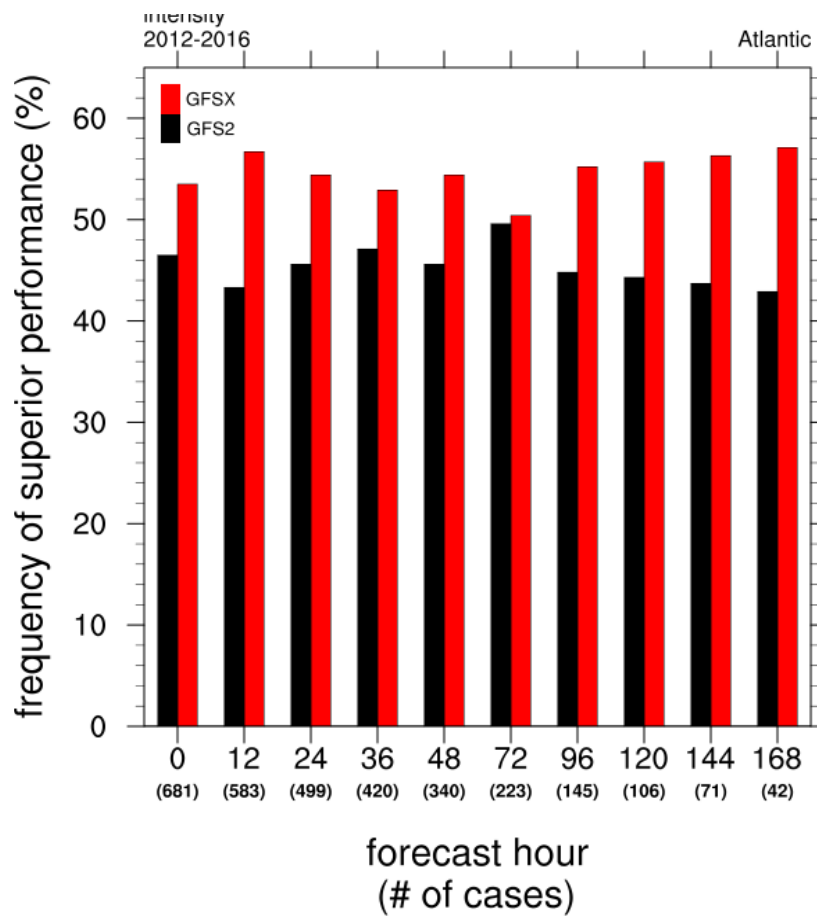


# Impact on Hurricanes: NHC Evaluation

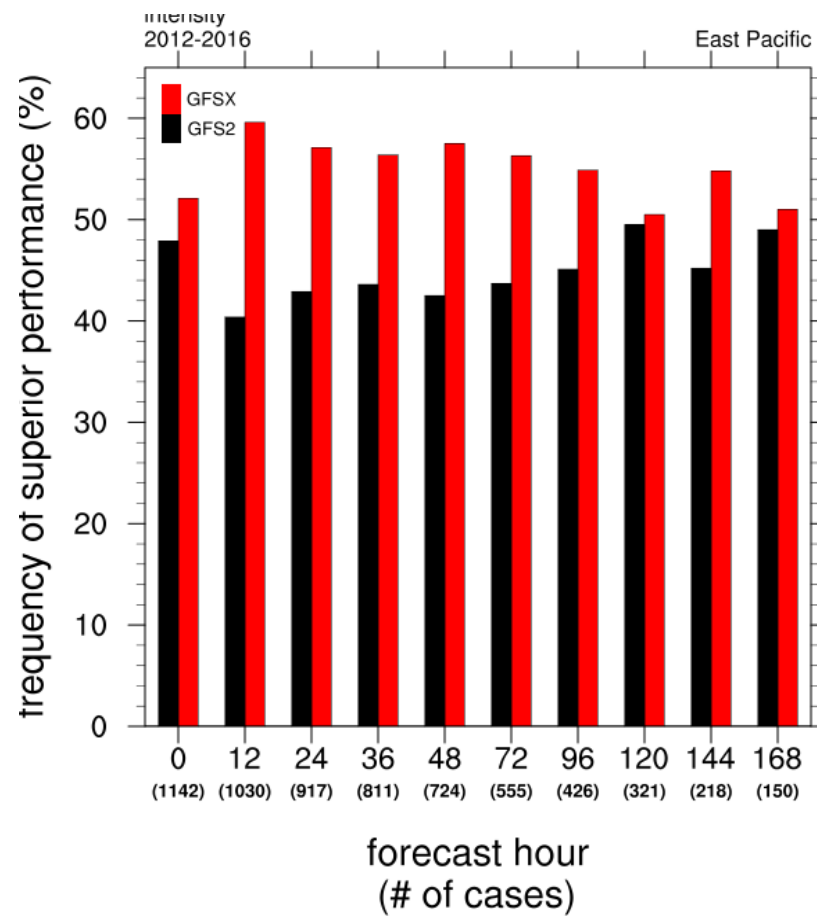
2012-2016

Frequency of Superior Performance - Intensity

## Atlantic



## East Pacific



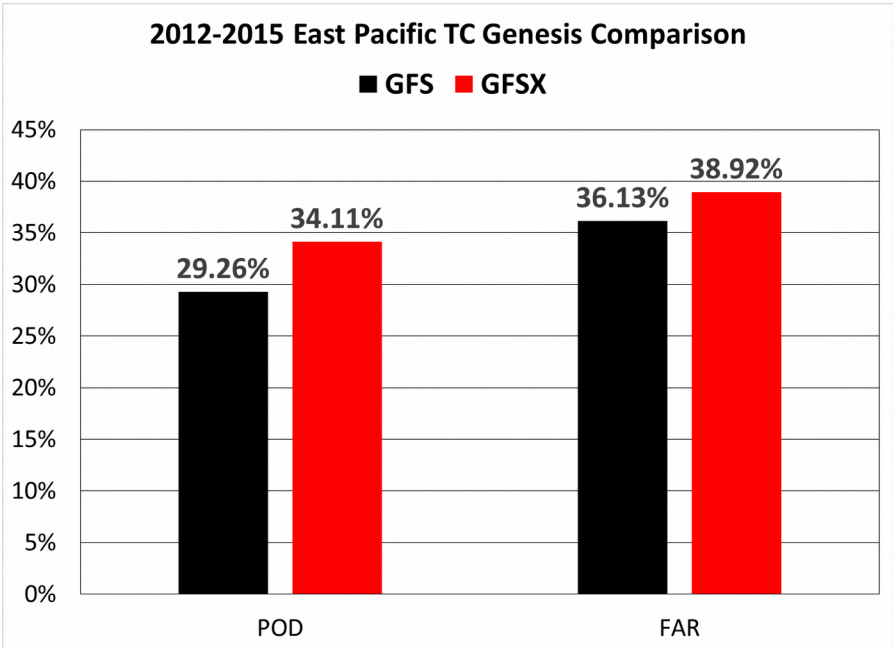
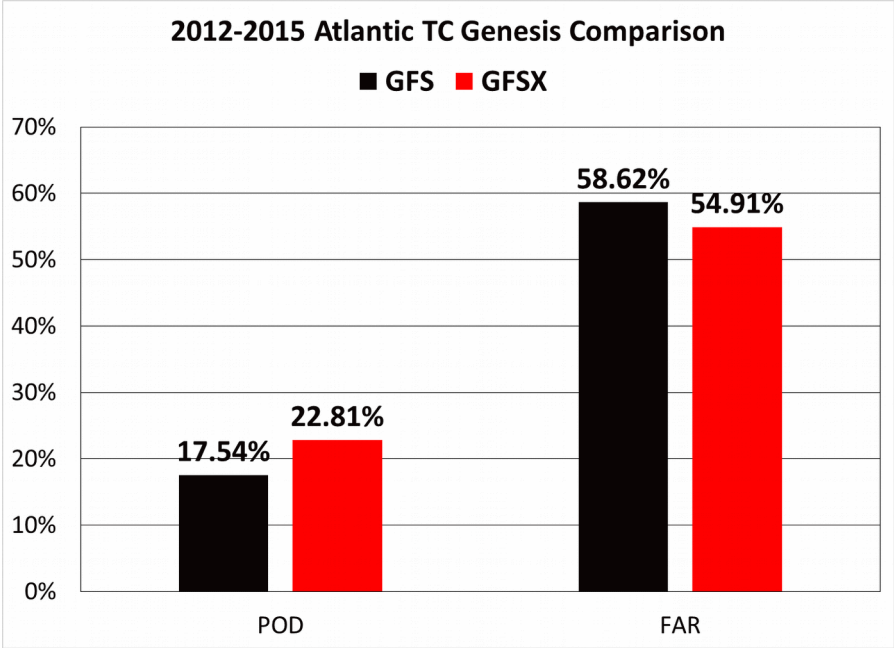
# Impact on Hurricanes: NHC Evaluation

<i>AL</i>	<i>Track</i>	<i>Intensity</i>
<i>0-48 h</i>	<i>- 3%</i>	<i>+5%</i>
<i>72-120 h</i>	<i>+7%</i>	<i>+ 11%</i>

<i>EP</i>	<i>Track</i>	<i>Intensity</i>
<i>0-48 h</i>	<i>+5%</i>	<i>+5%</i>
<i>72-120 h</i>	<i>+1%</i>	<i>+2%</i>

Track and intensity error improvements/degradation of Q3FY16 GFS vs. 2015 GFS for the 2012-2016 retrospective runs, by basin

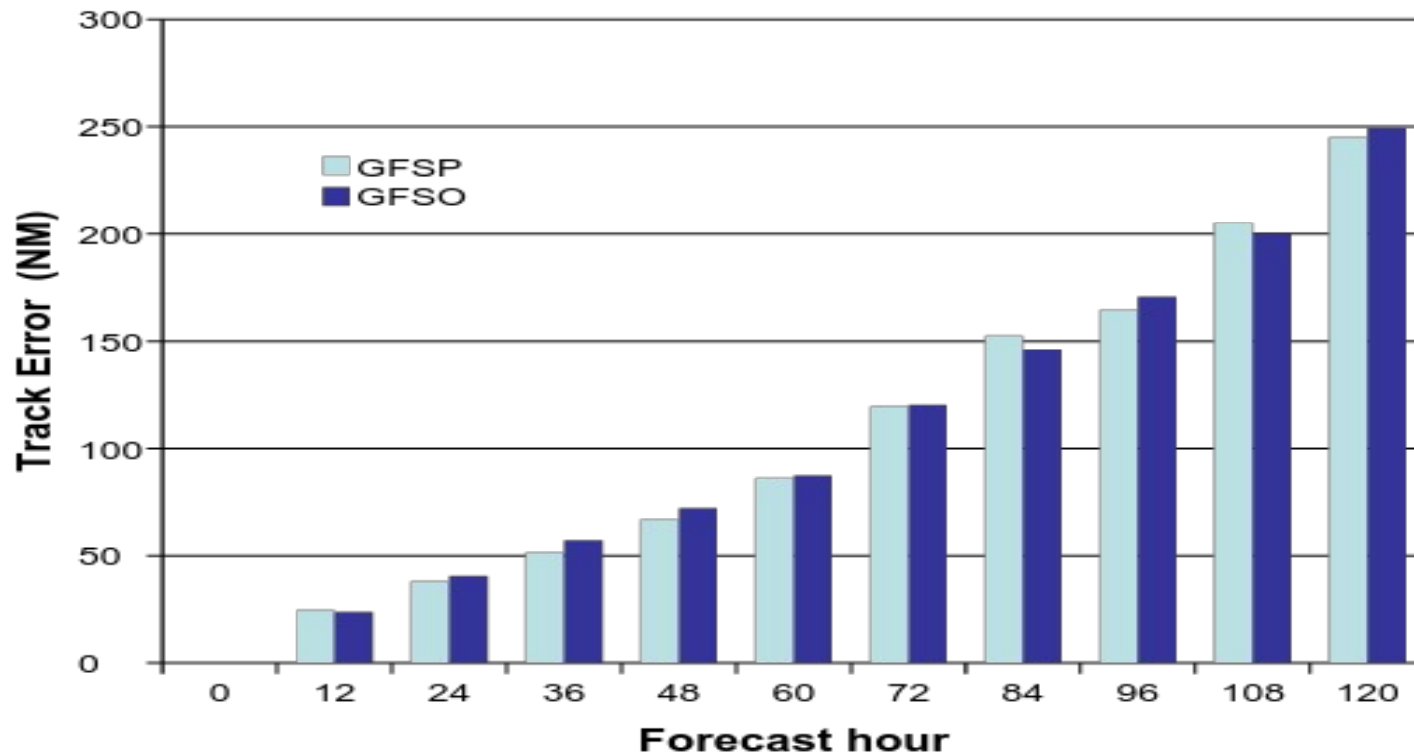
# Verification of TC cyclogenesis in the GFSX – comparison to current and previous version of the GFS (courtesy of Dan Halperin and Bob Hart)



# Comments from NHC and TAFB

- GFSP has mostly improved TC track and intensity forecasts in comparison to current GFS.
- GFSP in general handles gap wind events a little better than the current GFS, especially at longer time ranges.
- In comparison to the current GFS, the GFSP has a higher POD for TC genesis in both basins and a lower FAR in the Atlantic, but a higher FAR in the east Pacific – so overall the new GFS is better at predicting genesis.
- Based on limited cases with archived operational GFS on 1° grids and the retrospectives (GFSP) on 0.5° degree grids
- Results were a mixed bag, but the GFSP seemed to have an advantage at longer lead times
- Since the impact of the GFSP on the HWRF and GFDL hurricane models remains unknown, **NHC cannot endorse this implementation. However, NHC does not oppose it.**

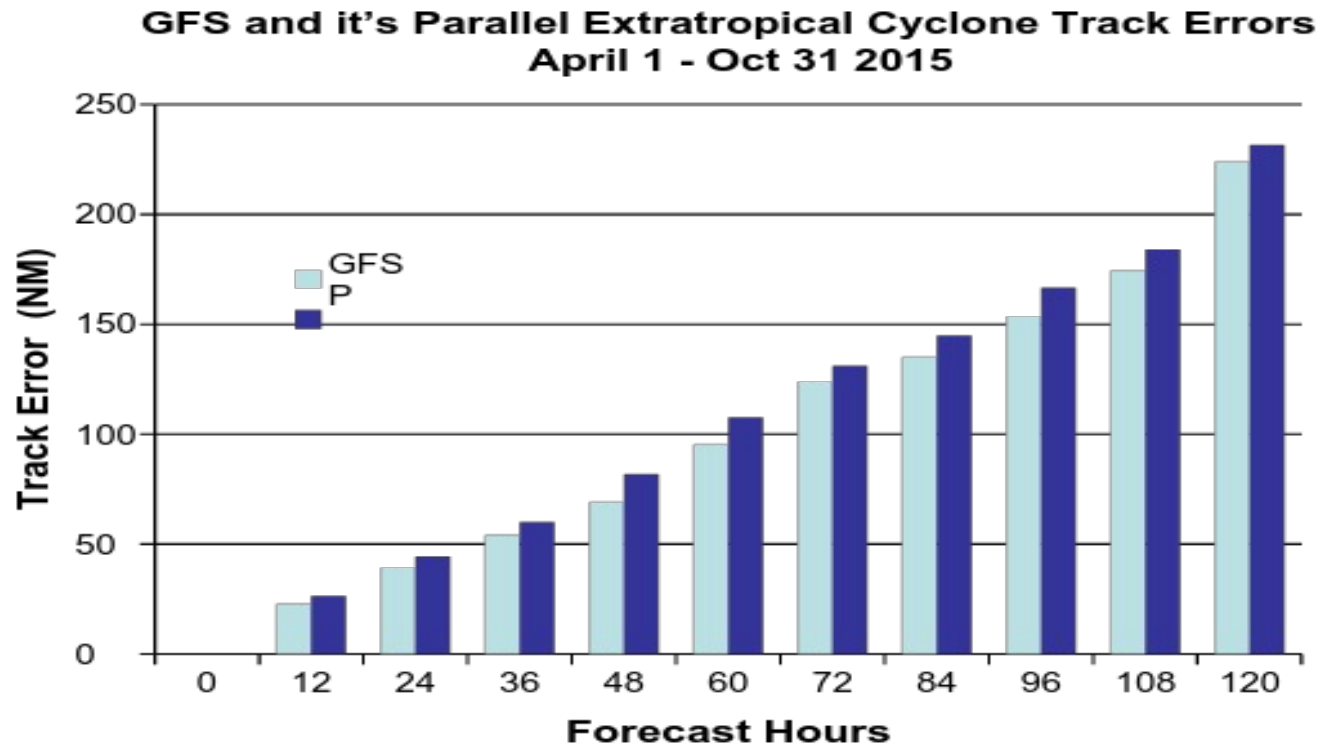
# GFS and GFSX Extratropical Cyclone Track Errors Nov.1 2013 - April 30 2014



GFSO (blue) - Control GFS; GFSX (cyan) - Parallel GFS

7 out 10 times, errors in GFSX are smaller than in GFSO.

Fcst hr	0	12	24	36	48	60	72	84	96	108	120
Cases	520	508	487	391	259	155	98	62	42	29	22



GFSO (blue) – Operational GFS (Control); GFSP (cyan) – Parallel GFS

**Errors in GFSX are smaller than in GFSO.**

Fcst hr	0	12	24	36	48	60	72	84	96	108	120
Cases	1093	1075	1011	687	366	201	104	64	35	26	17

# Case Studies from the Field: EMC Evaluation

## GFSX 6/9

## GFS 3/9

<i>Case</i>	<i>Model Performance</i>
<b><i>CR 1/29-2/2/2015</i></b>	<b><i>GFSX somewhat better</i></b>
<b><i>WR 10/3-10/4/2015</i></b>	<b><i>GFSX slightly better</i></b>
<b><i>WR 11/8-11/10/2014</i></b>	<b><i>GFS slightly better</i></b>
<b><i>WR 11/20-23/2014</i></b>	<b><i>GFSX better</i></b>
<b><i>WR 8/28-8/30/2015</i></b>	<b><i>GFSX slightly better</i></b>
<i>Case</i>	<i>Model Performance</i>
SR 12/5-12/6/2013	GFSX did better
CR 3/23/2015	GFSX did slightly better
CR 6/4-6/5/2015	GFS did slightly better
CR 7/6/2015	GFS did slightly better

# Typhoon Astani Findings

Focus on 12Z 8/20/15 cycle

Forecasts 108-192 valid 00Z 8/25/15 – 00Z 8/29/15

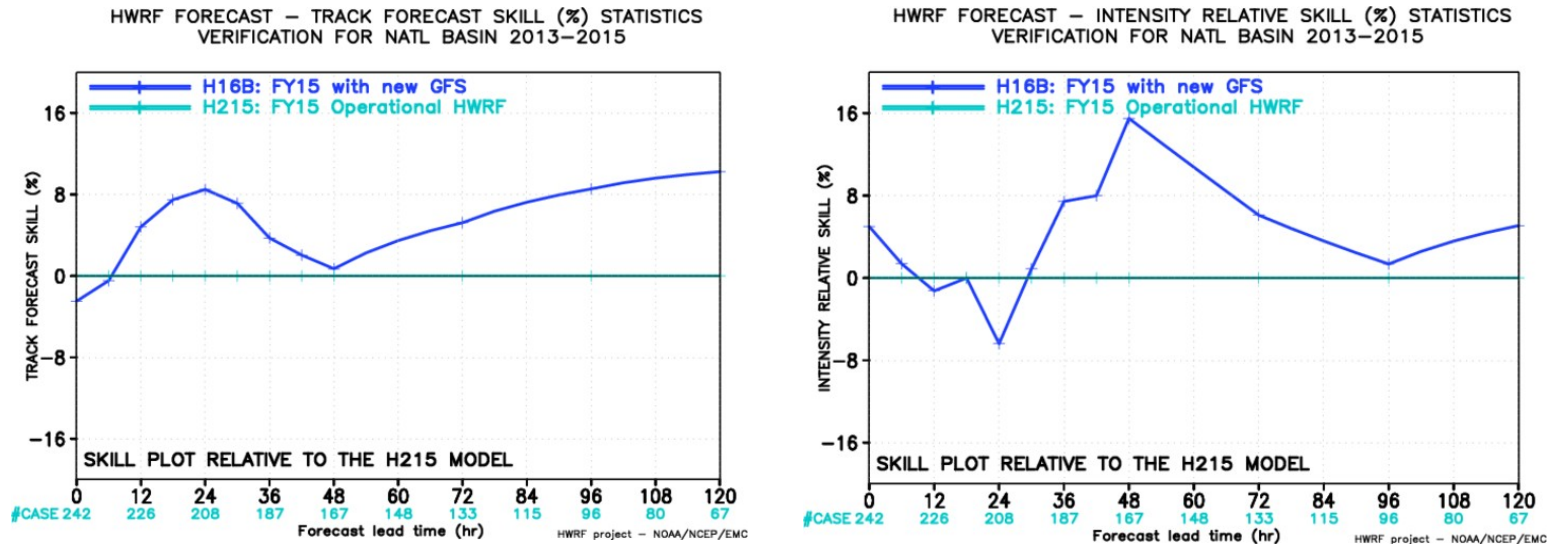
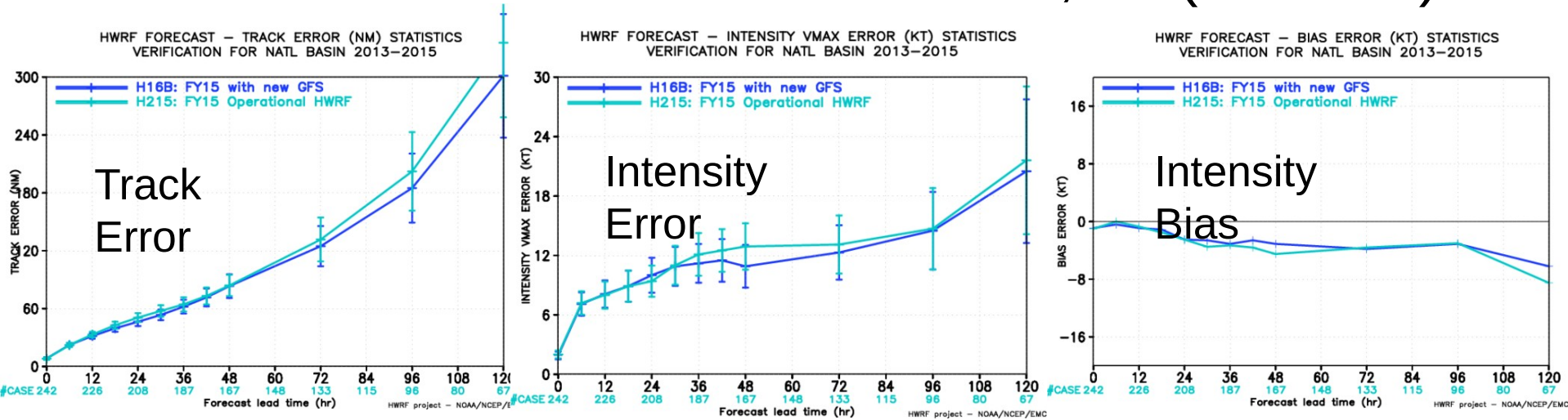
- Starting with 108-h forecasts and going to 204-h, GFS too far to the north and east, then too far to the east, followed by too far to the north (except for 204-h forecast, GFS too far south)
- Starting with the 108-h forecasts and going to 204-h, GFSX started off with good position for Atsani, then was too far south and east, then slightly too far north, was too far south for 204-h forecast
- In general, the GFSX was closer to analysis

<i>Forecasts</i>	<i>GFS</i>	<i>GFSX</i>
<b>108</b>		✓
<b>120</b>		✓
<b>132</b>		✓
<b>144</b>	✓	✓
<b>156</b>		✓
<b>168</b>	✓	
<b>180</b>		✓
<b>192</b>		✓
<b>204</b>	✓	

\* Extra-tropical transition  
around 12Z 8/25/15

<b><i>WPC Case Studies</i></b>	<b><i>Remarks</i></b>
<b><i>Tornado outbreak over Kansas, Texas Nov. 16-17, 2015</i></b>	<b><i>GFSX better in forecast from 000 GMT Nov. 16</i></b>
<b><i>Sandy Oct .22-30, 2012</i></b>	<b><i>GFS, GFSX track errors similar</i></b>
<b><i>Joaquin Sept. 25-Oct. 4, 2015</i></b>	<b><i>GFSX better track, adopted out to sea track 6 hours before operational GFS</i></b>
<b><i>South Carolina flooding Oct. 3, 4, 2015</i></b>	<b><i>GFS, GFSX similar</i></b>
<b><i>GFS dry bias in southeast US autumn 2015, winter 2015-2016</i></b>	<b><i>GFS, GFSX similar</i></b>
<b><i>GFS cold bias over snow cover</i></b>	<b><i>GFS, GFSX similar</i></b>
<b><i>Blizzard Jan. 22-23, 2016</i></b>	<b><i>GFS, GFSX similar</i></b>
<b><i>Warm, dry bias Great Plains 000 GMT Aug. 16</i></b>	<b><i>GFSX better</i></b>
<b><i>New England blizzard Jan 26-27 2015</i></b>	<b><i>GFSX better 2.5 day forecast</i></b>

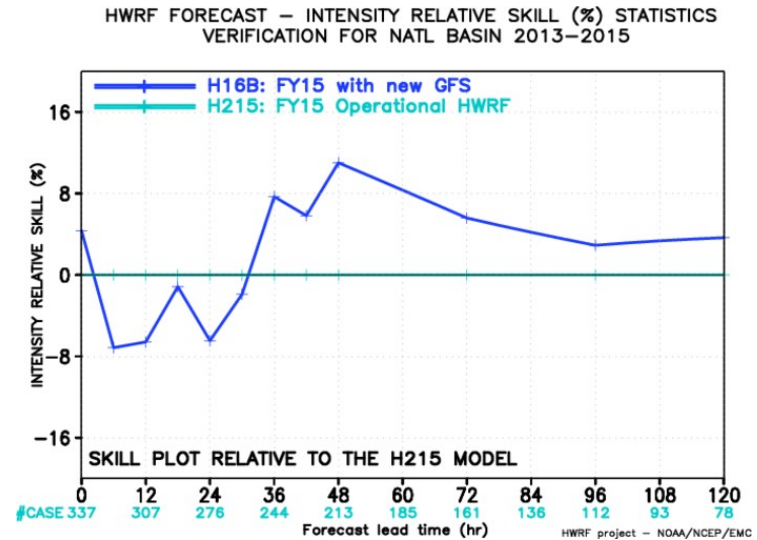
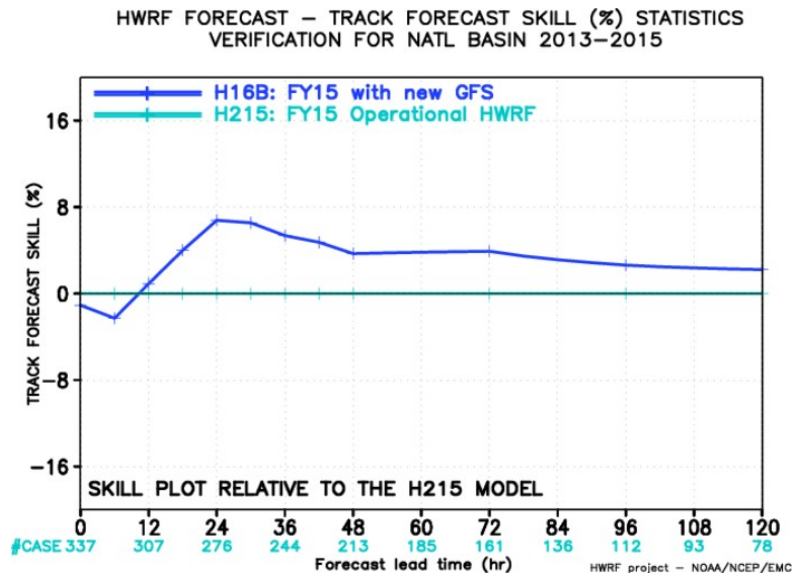
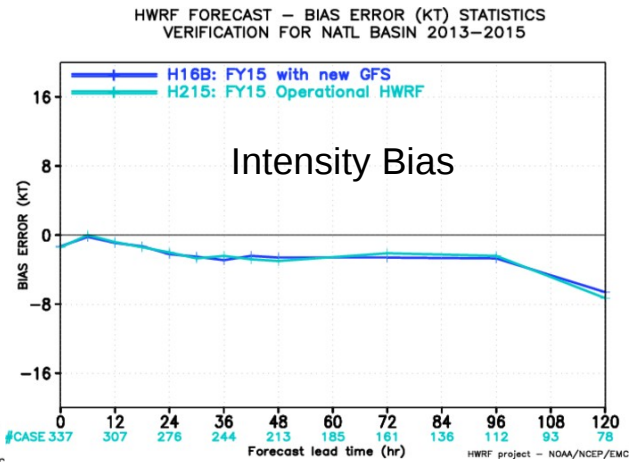
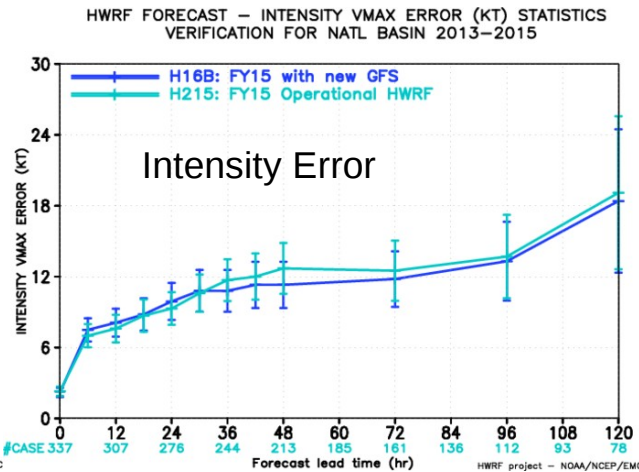
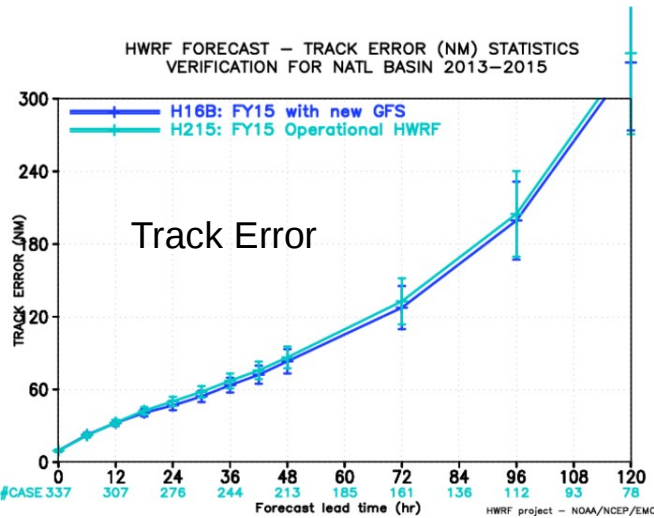
# HWRF Evaluation: H16B vs. H215, AL (242/578)



Track Skill  
improvement

Intensity Skill  
improvement

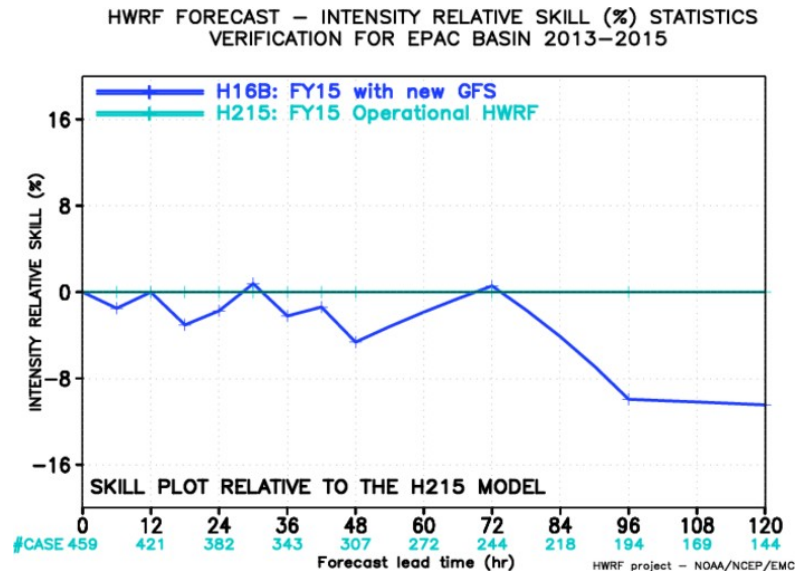
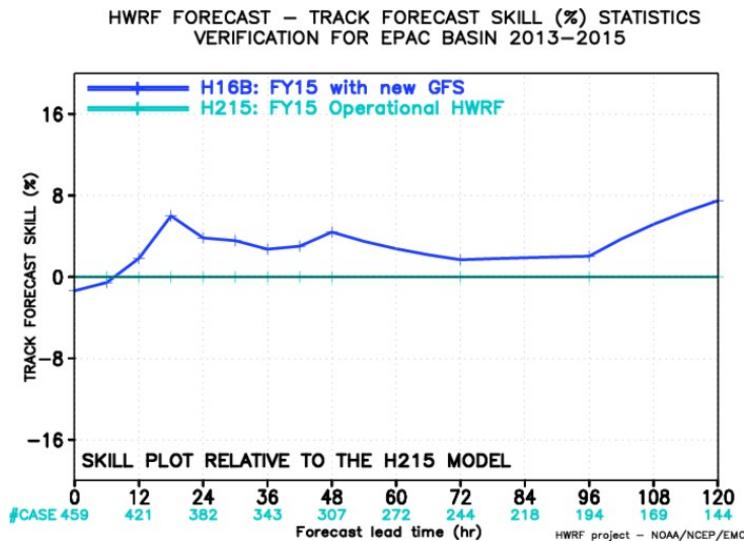
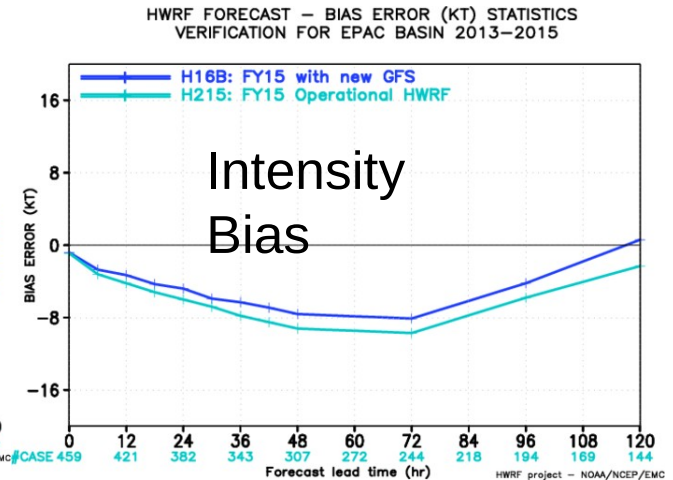
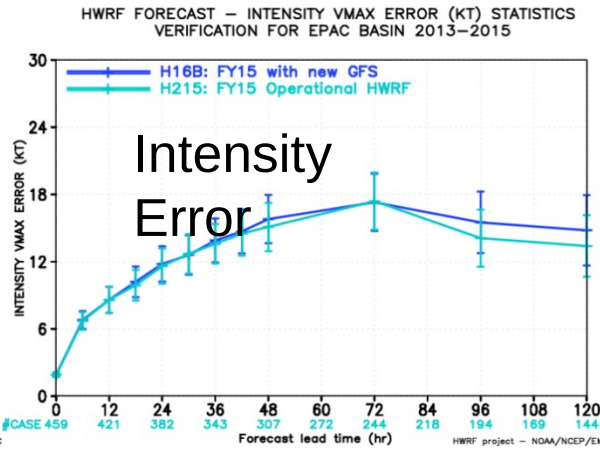
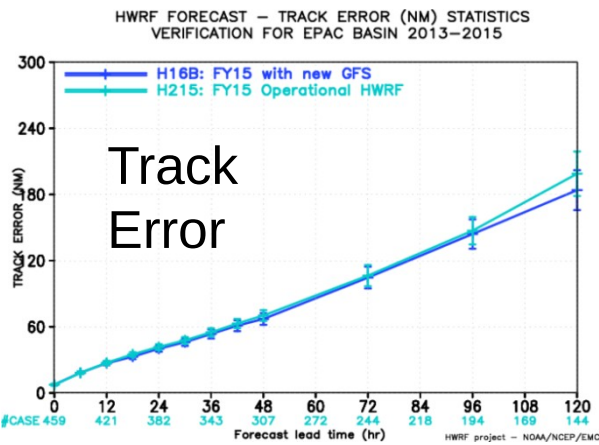
# H16B vs. H215, AL (337/578)



Track Skill improvement

Intensity Skill improvement

# HWRF Evaluation: H16B vs. H215, EP (459/942)

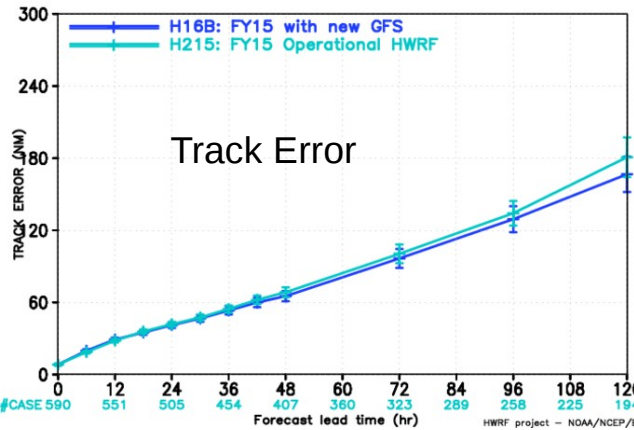


Track Skill  
improvement

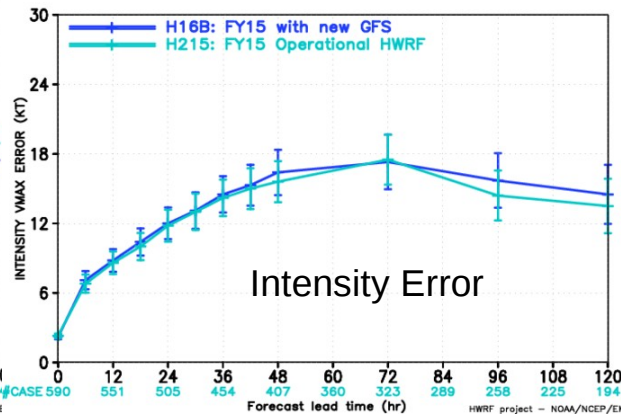
Intensity Skill  
improvement

# H16B vs. H215, EP (590/942)

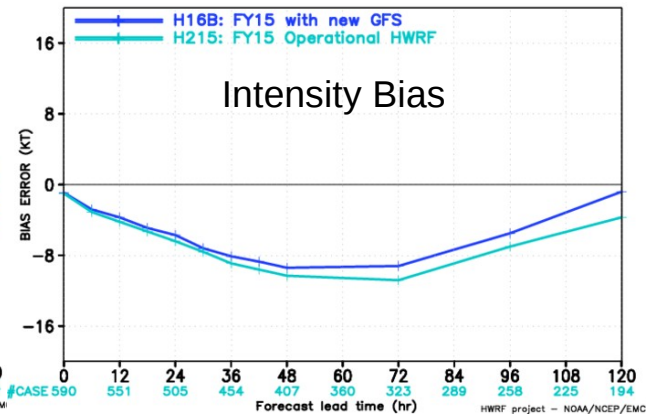
HWRP FORECAST — TRACK ERROR (NM) STATISTICS  
VERIFICATION FOR EPAC BASIN 2013–2015



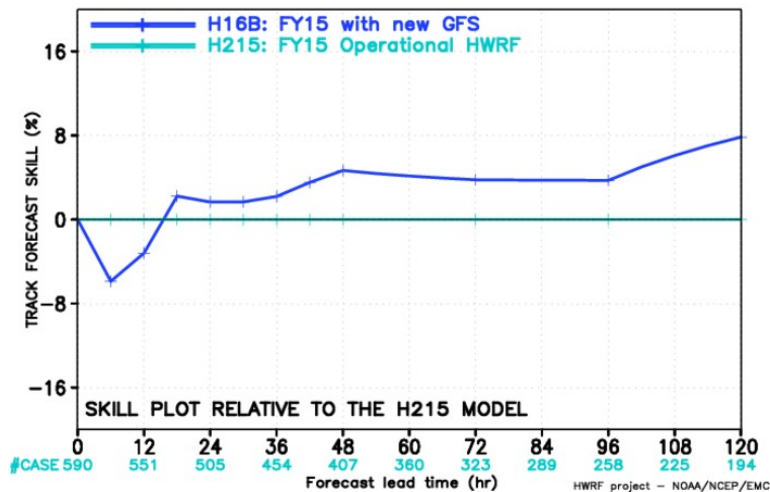
HWRP FORECAST — INTENSITY VMAX ERROR (KT) STATISTICS  
VERIFICATION FOR EPAC BASIN 2013–2015



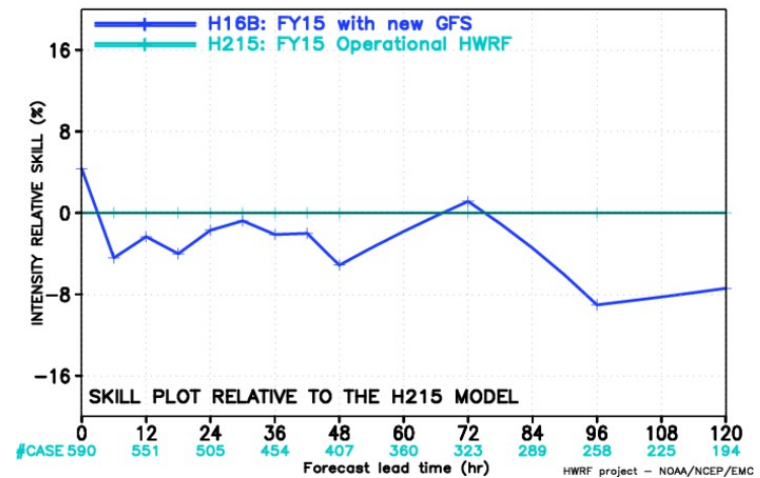
HWRP FORECAST — BIAS ERROR (KT) STATISTICS  
VERIFICATION FOR EPAC BASIN 2013–2015



HWRP FORECAST — TRACK FORECAST SKILL (%) STATISTICS  
VERIFICATION FOR EPAC BASIN 2013–2015



HWRP FORECAST — INTENSITY RELATIVE SKILL (%) STATISTICS  
VERIFICATION FOR EPAC BASIN 2013–2015



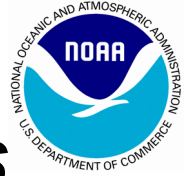
Track Skill improvement

Intensity Skill improvement



# Endorsements from Stakeholders

<b><i>Region/Center</i></b>	<b><i>Recommendation</i></b>	<b><i>Remarks</i></b>
<b><i>Western Region</i></b>	<b><i>Implement</i></b>	<b><i>Neutral</i></b>
<b><i>Central Region</i></b>	<b><i>Implement with reservations</i></b>	<b><i>Little improvement</i></b>
<b><i>Southern Region</i></b>	<b><i>Implement</i></b>	<b><i>No striking differences</i></b>
<b><i>Eastern Region</i></b>	<b><i>Implement</i></b>	<b><i>Minor improvements</i></b>
<b><i>Pacific Region</i></b>	<b><i>Implement</i></b>	<b><i>Models performed well with Winston</i></b>
<b><i>Alaska Region</i></b>	<b><i>Implement</i></b>	<b><i>No specific problems</i></b>
<b><i>WPC</i></b>	<b><i>Implement</i></b>	<b><i>Similar, GFSX slightly better sometimes</i></b>
<b><i>NHC</i></b>	<b><i>Neither endorse nor oppose</i></b>	<b><i>Improved tropical forecasts,</i></b>  <b><i>downstream tests incomplete</i></b>



# ***Endorsements from Stakeholders***

<b><i>Region/Center</i></b>	<b><i>Recommendation</i></b>	<b><i>Remarks</i></b>
<b><i>AWC</i></b>	<b><i>Implement</i></b>	<b><i>Better winds, temperatures</i></b>
<b><i>CPC</i></b>	<b><i>Implement</i></b>	<b><i>Large errors upper stratosphere</i></b>
<b><i>OPC</i></b>	<b><i>Implement</i></b>	<b><i>Extratropical storm tracks better</i></b>
<b><i>SWPC</i></b>	<b><i>Implement</i></b>	<b><i>Need improvements in upper atmosphere</i></b>
<b><i>MDL</i></b>	<b><i>Implement</i></b>	<b><i>Redeveloped MOS better</i></b>
<b><i>NWC</i></b>	<b><i>Implement</i></b>	<b><i>Hourly files should improve NWC fcsts</i></b>
<b><i>SPC</i></b>	<b><i>Implement</i></b>	<b><i>Improved in warm season</i></b>
<b><i>Weather It Is Ltd. (Prof. Barry Lynn)</i></b>	<b><i>under situations where the observational network is more dense, there has been improvement in the initial state (and lateral boundary conditions) of the GFSX compared to GFS</i></b>	
<b><i>AccuWeather</i></b>	<b>Hourly output is of significant value for Weather Industry</b>	



# EMC/GCWMB Assessment

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- Positive evaluation (significantly positive improvements in majority of the metrics)
- DA upgrades have been effective in reducing the forecast errors in the short-range, and improving analysis increment for almost all prognostic variables
- Results shown significant improvement in week 1 forecasts verified against own analyses except for heights and temperatures in stratosphere
- Rain no rain forecasts worse, but overall conus precipitation improved significantly



# EMC/GCWMB Assessment

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- 2m temperature, dewpoint, 10 m wind forecasts against station obs over CONUS, Alaska improved.
- CAPE forecasts over CONUS improved
- Forecasts of tropical storm genesis. track and intensity forecasts improved.
- Mode verification of CAPE, Jet Streams, QPF and winds shows GFSX slightly better
- Synoptic evaluations of GFSX produced no red flags. GFSX, GFS similar; GFSX slightly better in some cases
- Forecasts of heights, temperatures, winds significantly improved **except for heights and temperatures in stratosphere. Large errors in upper stratosphere**
- CONUS precipitation forecasts improved for thresholds of 2-25 mm/day, **worse for thresholds of 0.2 mm/day**



# Hourly Output from GFS through 120 hrs & Additional Fields



- Hourly GFS forecast output at 0.25 deg. resolution (grib2) will be made available through 120 hr (ftp only)
- GFS Post is adding output on 5 more pressure levels in stratosphere **1, 2, 3, 5, and 7 mb** per request of CPC.

Each additional level has 6 records:

- Geopotential Height (HGT); Temperature (TMP); Relative Humidity (RH);
- U- and V Components of Wind (UGRD & VGRD)
- Ozone Mixing Ratio (O3MR)
- Two New Products: Icing probability and Icing Severity are also added to Aviation Weather (WAFS)

# Q3FY16 GFS/GDAS New Vertical Structure

<https://svnemc.ncep.noaa.gov/projects/gfs/branches/>

gdas.v13.0.0	gfs.v13.0.0	global_shared.v13.0.0	Included Packages
<p>parm ush sorc  <i>Jobs</i> scripts exec</p> <p>JGDAS_TROPCY_QC_RELOC JGDAS_NCEPPOST JGDAS_EMCSFC_SFC_PREP JGDAS_TROPC JGDAS_MKNAVYBULLS JGDAS_GEMPAK_META JGDAS_BULLS JGDAS_GEMPAK_NCDC JGDAS_GEMPAK JGDAS_ENKF_INFLATE_RECENTER JGDAS_ANALYSIS_HIGH JGDAS_ENKF_SELECT_OBS JGDAS_ENKF_UPDATE JGDAS_ENKF_POST JGDAS_ENKF_INNOVATE_OBS JGDAS_ENKF_FCST JGDAS_FORECAST_HIGH</p>	<p>parm ush sorc  <i>Jobs</i> scripts exec</p> <p>JGFS_PRDGEN_MANAGER JGFS_POST_MANAGER JCPC_GET_GFS_6HR JGFS_NPOESS_PGRB2_0P5DEG JGFS_CYCLONE_TRACKER JGFS_FBWIND JGFS_AWIPS_G2 JGFS_PGRB2 JGFS_AWIPS_20KM JGFS_AWIPS_1P0DEG JGFS_TROPCY_QC_RELOC JGFS_PGRB2_SPEC_POST JGFS_SMINIT JGFS_NCEPPOST JGFS_EMCSFC_SFC_PREP JGFS_WAFS_GRIB2 JGFS_WAFS JGFS_WAFS_BLENDING JGFS_WAFS_GCIP JGFS_PGRB2_SPEC_GEMPAK JGFS_GEMPAK_UPAPGIF JGFS_GEMPAK_NCDC JGFS_POSTSND JGFS_GEMPAK_META JGFS_FAX JGFS_ANALYSIS JGFS_FORECAST_LOW JGFS_FAX_WAFS JGFS_GEMPAK JGFS_FORECAST_HIGH</p>	<p>parm ush sorc  scripts exec</p> <p>No jobs</p>	<p>GSI &amp; Enkf (analysis) GSM (forecast) ncep_post emcsfc tropcy_qc_relo wafs gfs_post (downstream) Gempak (downstream) smartinit misc</p> <p>Will be included</p> <p>MinMon (monitoring) RadMon (monitoring)</p>

Unification of EMC parallels with NCO Operational structure

# Q3FY16 GFS/GDAS New Vertical Structure

<https://svnemc.ncep.noaa.gov/projects/gfs/branches/>

gdas.v13.0.0	gfs.v13.0.0	global_shared.v13.0.0	Included Packages
<p>parm ush <b>sorc</b>  Jobs scripts exec</p> <p>Getsigensmeanp _smooth_ncep.fd recentersigp.fd Adderrspec _nmcmeth_spec.fd getsfcensmeanp.fd enkf_update.fd build_enkf.sh gdas_trpsfcmv.fd gridbull.fd navybull.fd build_gdas_gridbull.sh build_gdas_navybull.sh build_gdas_trpsfcmv.sh</p>	<p>parm ush <b>sorc</b>  Jobs scripts exec</p> <p>awc_wafavn.fd gcip.fd wafs_blending.fd build_wafs_wcross.sh cnvgrib2_wafs.fd gfs_bufr.fd tocsbufr.fd smartprecip.fd smartinit.fd overpdtg2.fd gfs_flux.fd build_smartinit_wcross.sh build_tocsbufr _gfs_flux_wcross.sh wintemv.fd makewafs.fd fbwndgfs.fd build_gfs_wintemv.sh build_gfs_overpdtg2.sh build_gfs_fbwndgfs.sh</p>	<p>parm ush <b>sorc</b>  scripts exec</p> <p>ncep_post.fd supvit.fd tave.fd gettrk.fd syndat_getjtbul.fd syndat_maksynrc.fd vint.fd gsi.fd emcsfc_ice_blend.fd relocate_mv_nvortex.fd emcsfc_snow2mdl.fd syndat_qctropcy.fd build_ncep_post.sh build_emcsfc.sh build_tropcy.sh build_gsi.sh global_sfchdr.fd global_chgres.fd global_sighdr.fd global_cycle.fd global_fcst.fd build_gsm_wcross.sh</p>	<p>GSI &amp; Enkf (analysis) GSM (forecast) ncep_post emcsfc tropcy_qc_relo wafs gfs_post (downstream) Gempak (downstream) smartinit misc</p> <p><b>Will be included</b></p> <p>MinMon (monitoring) RadMon (monitoring)</p>

Unification of EMC parallels with NCO Operational structure



# GCWMB requests EMC Director to approve implementation of Q3FY16 GDAS/GFS upgrade package.

Special acknowledgements:

John Derber, Russ Treadon, Glenn White, Fanglin Yang, Tracey Dorian, Partha Bhattacharjee, Lin Gan, Boi Vuong, Qingfu Liu, Guangping Liu, Diane Stokes, Dennis Keyser, Yali Mao, Eugene Mirvis, George Gayno, Zhan Zhang, Lin Zhu, Cathy Thomas, Ed Safford, Rahul Mahajan, Jeff Whitaker, Yuejian Zhu, Steven Earle, Jen Yang & Becky Cosgrove



# Next Steps

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- Code Hand-off to NCO: **Completed**
- All non-GFS downstream codes submitted to NCO: **Completed**
- Collect Evaluation Reports from the field: **Completed**
- Final EMC CCB: Today (**Completed**)
- OD Briefing: 3/17/16 (**Scheduled**)
- TIN: 4/1/2016 (**on track**)
- 30-day evaluation: 4/06 – 5/5
- Final OD Briefing by NCO: 5/11
- Implementation: 5/17



# Backup Slides



# Fit to Obs Evaluation with aircraft Obs

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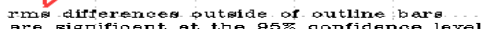
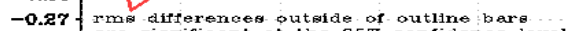
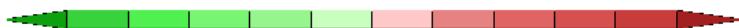
GFSX analyzed temperatures fit aircraft obs better all 3 layers  
forecast temperatures fit aircraft obs better in upper and lower layers

GFSX analyzed and forecast winds fit aircraft obs better in all 3 layers

GFSX analyzed temperatures fit ACARS obs better in all 3 layers  
forecast temperatures fit ACARS obs better in lower layer

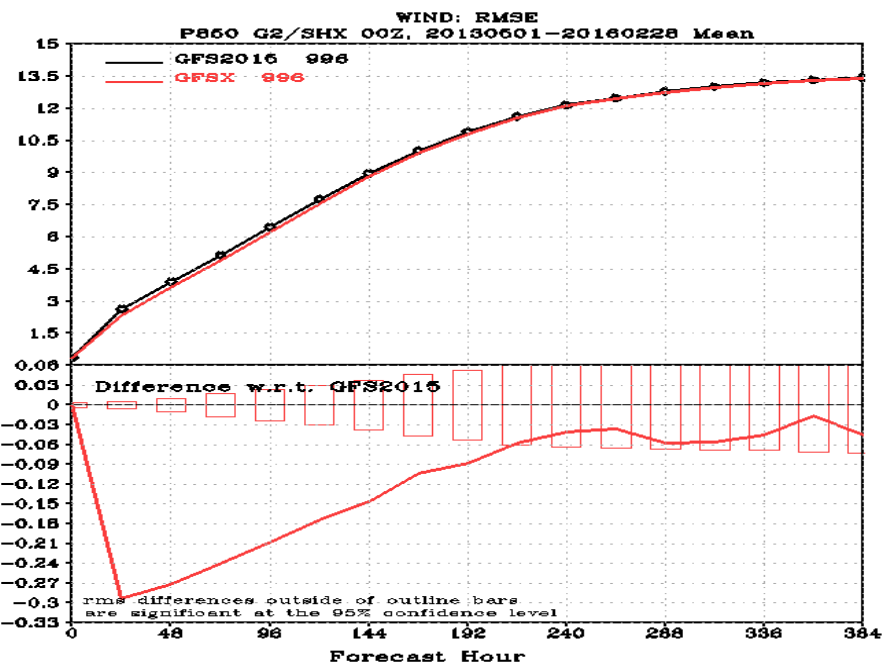
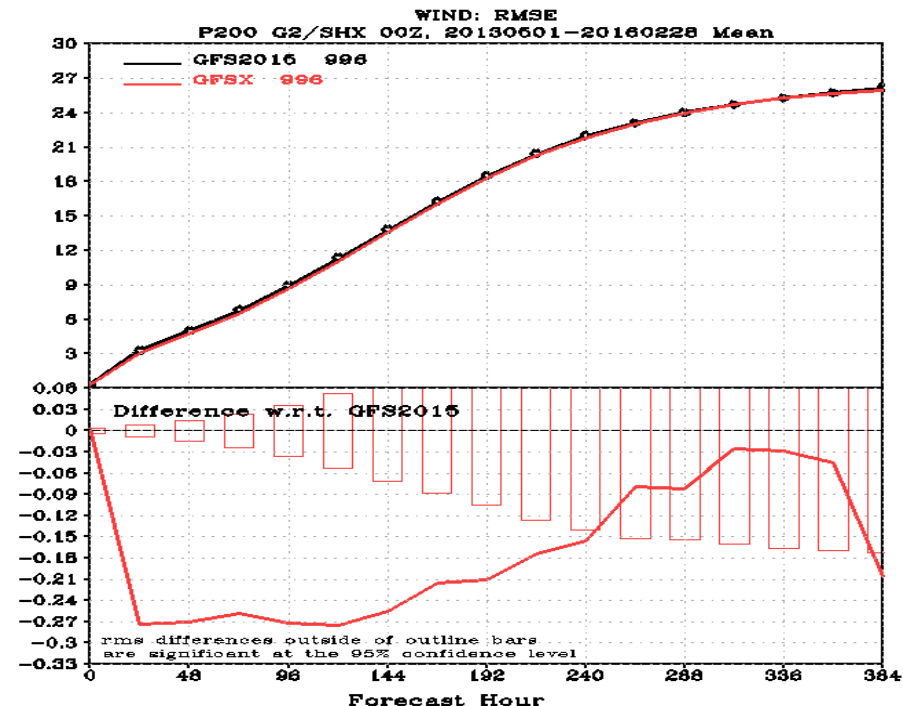
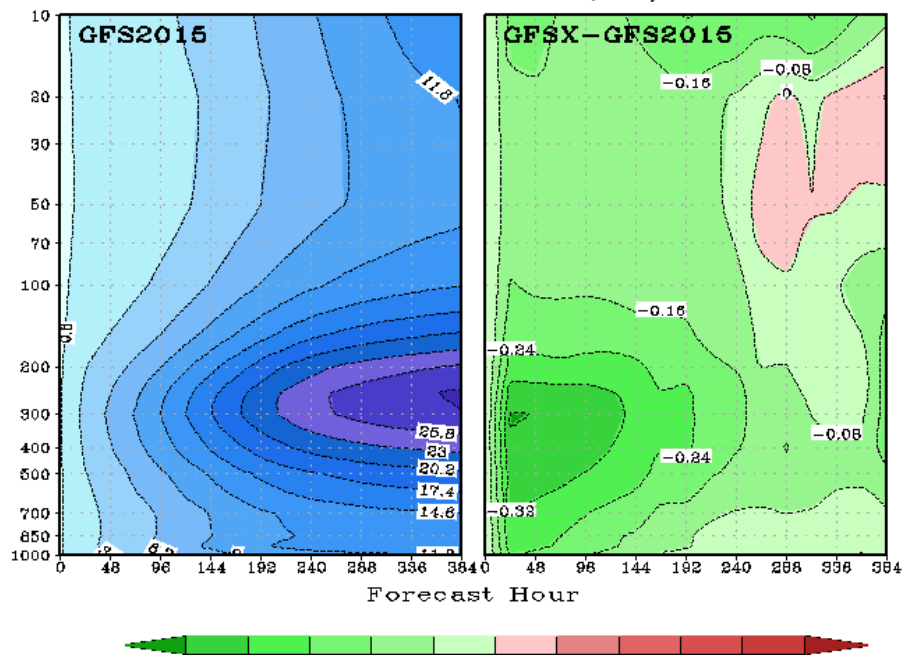
GFSX analyzed and forecast winds fit ACARS obs better in all 3 layers

WIND: RMSE



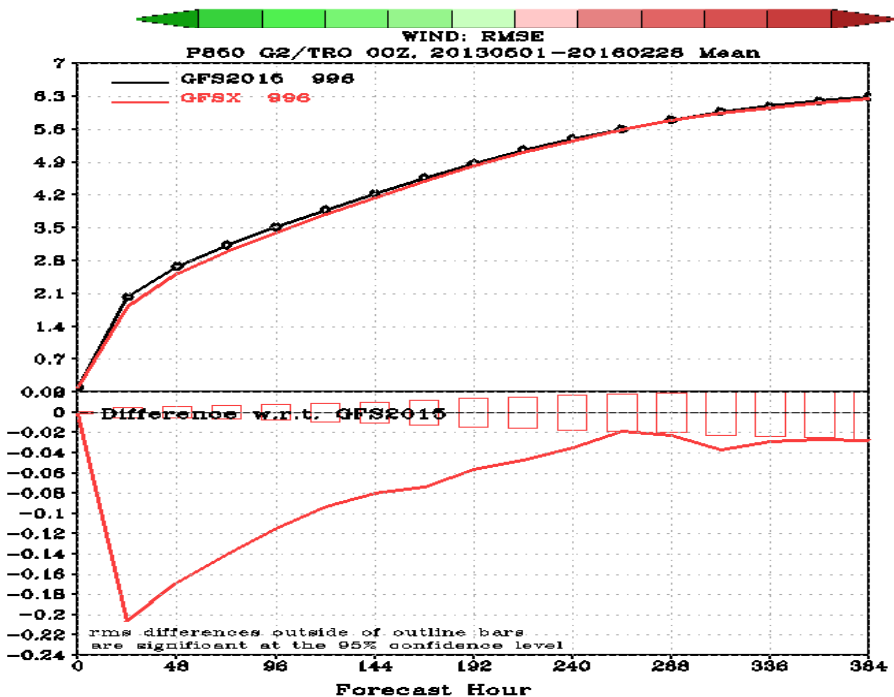
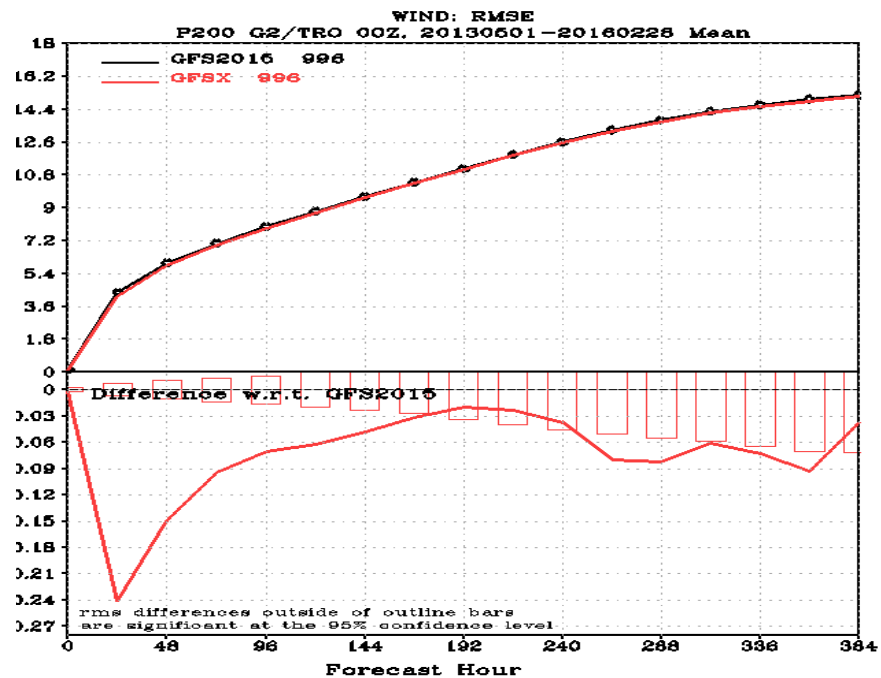
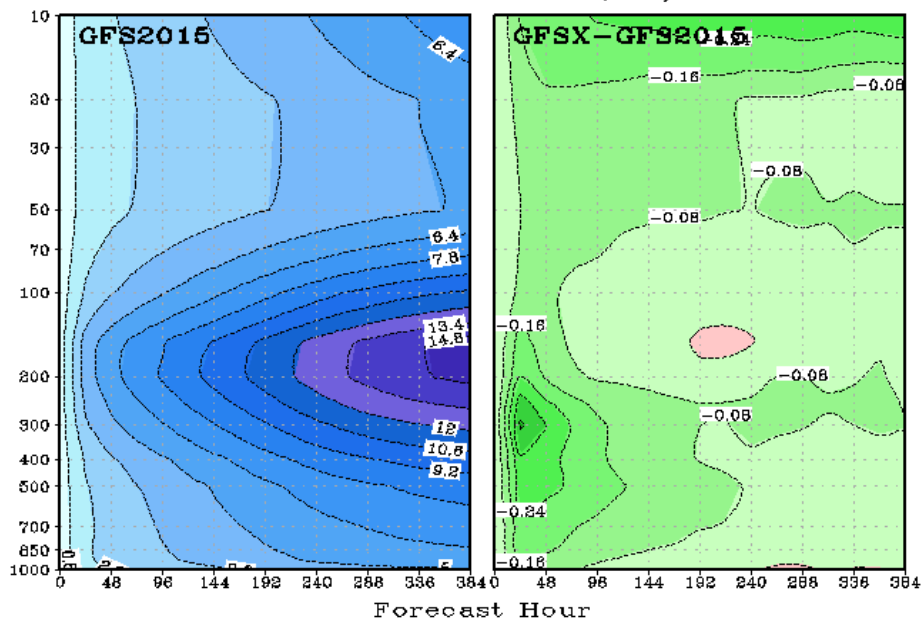
## Northern Hemisphere Winds RMSE

WIND: RMSE  
20130501-20160228 Mean, G2/SHX 00Z



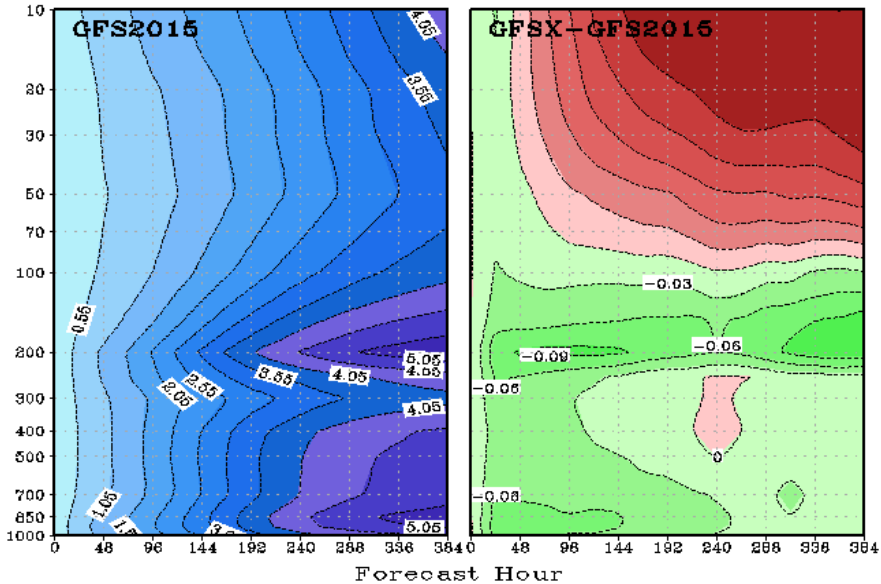
Southern Hemisphere  
Winds RMSE

WIND: RMSE  
20130501-20160228 Mean, G2/TRO 00Z

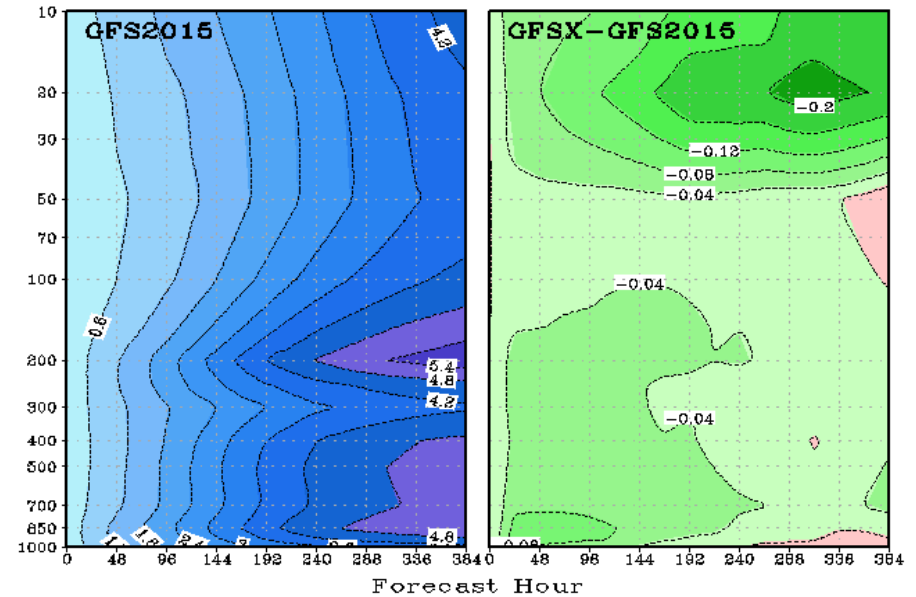


Global Tropics  
Winds RMSE

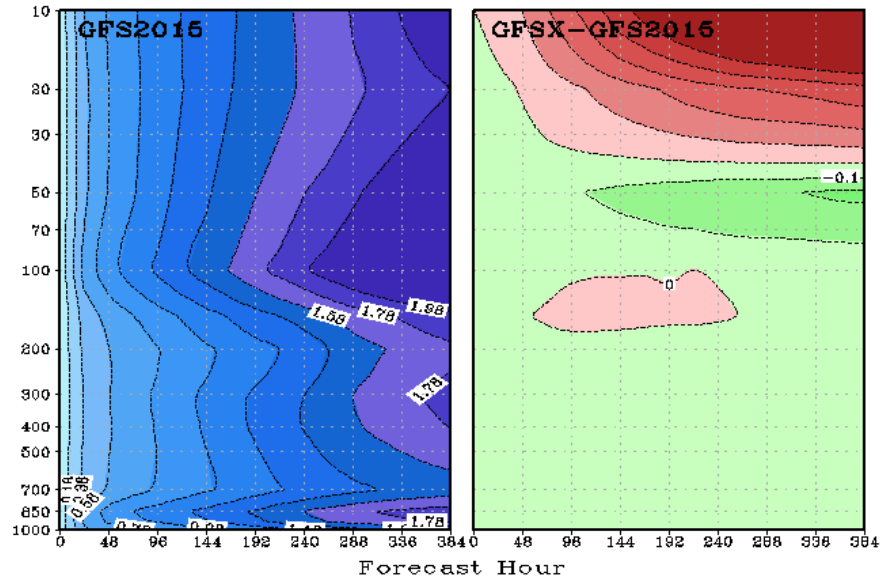
T: RMSE  
20130501-20160228 Mean, G2/NHX 00Z



T: RMSE  
20130501-20160228 Mean, G2/SHX 00Z



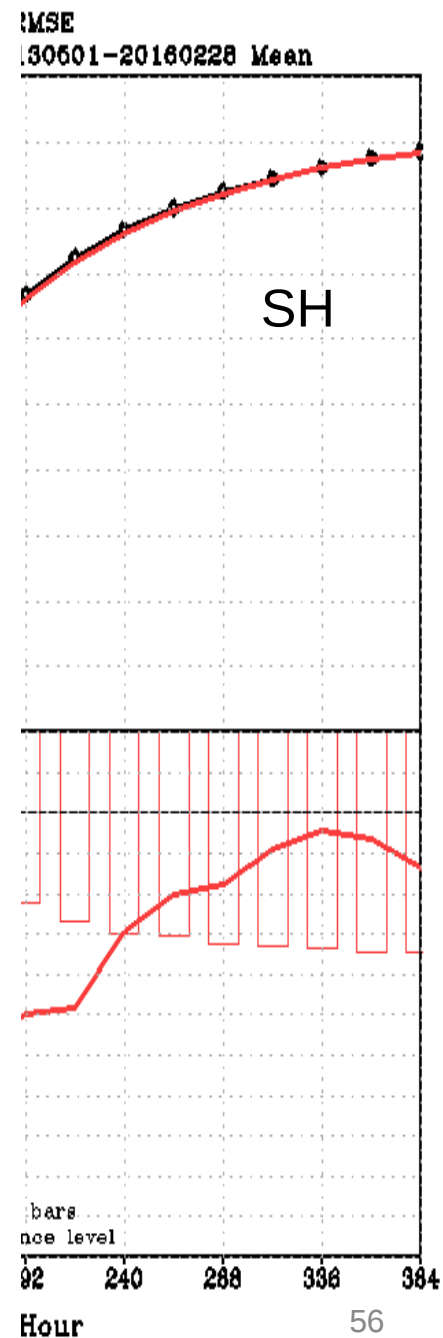
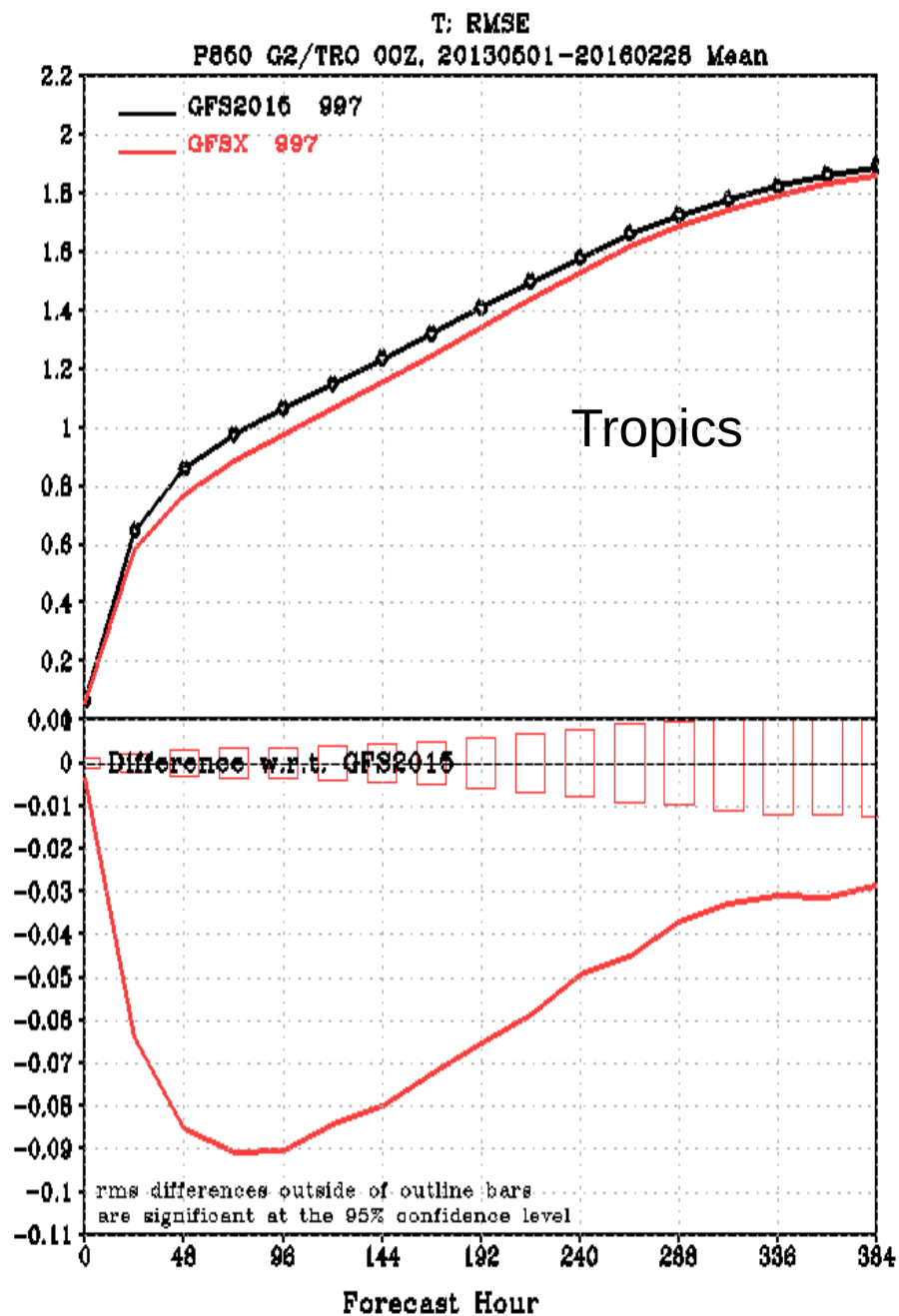
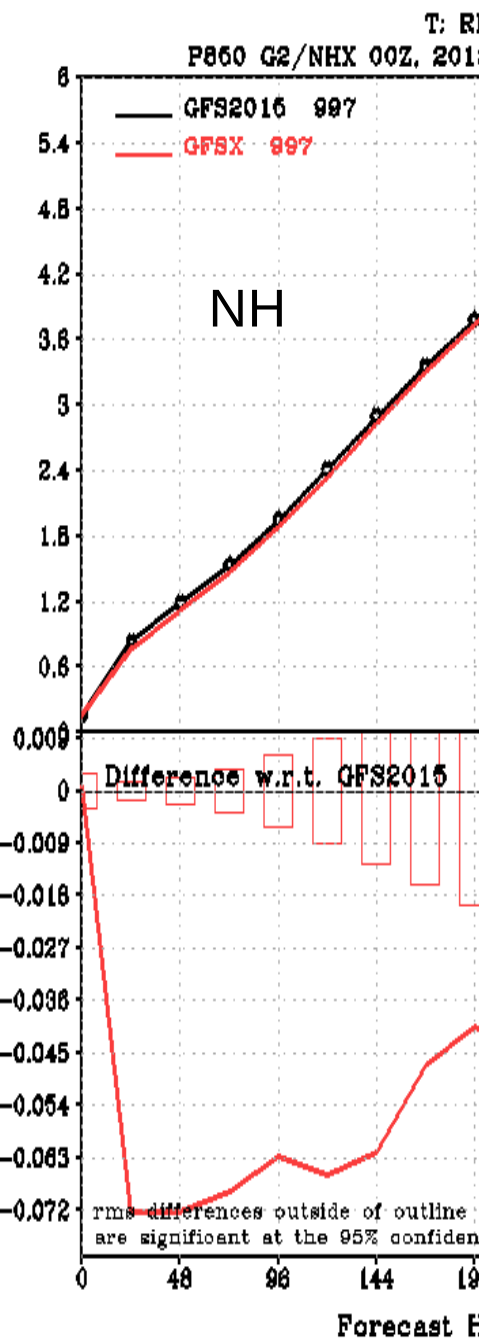
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Temperature RMSE

Big improvements in Southern Hemisphere

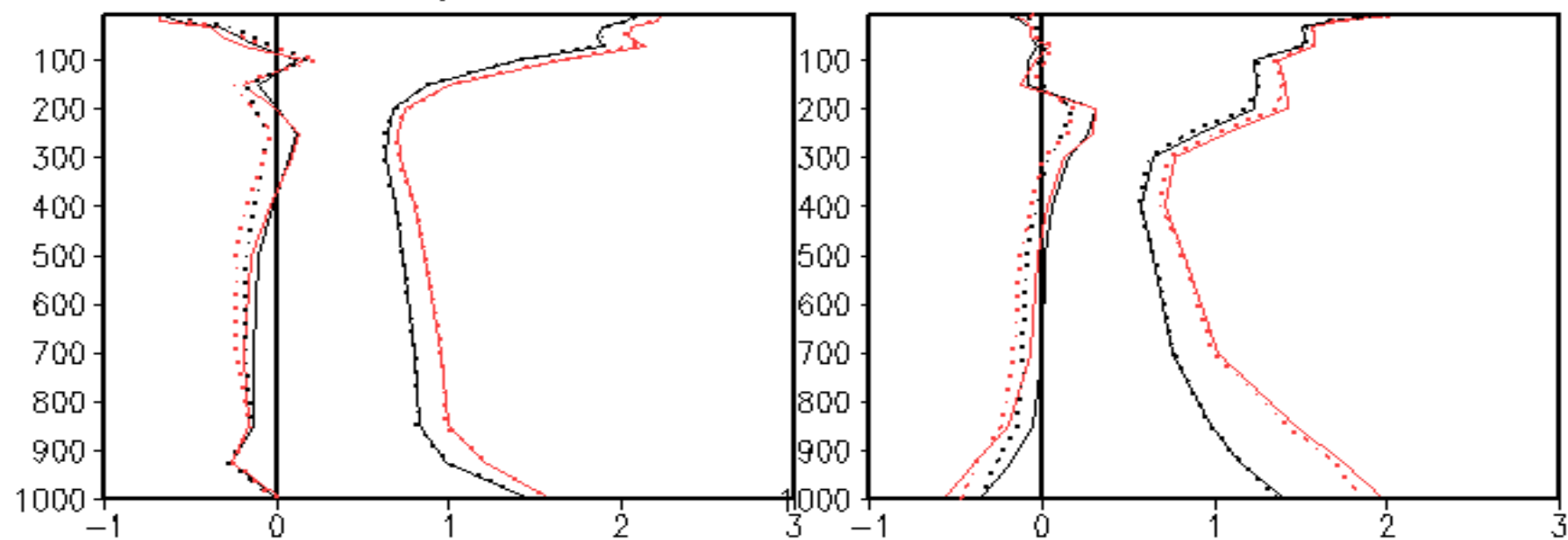
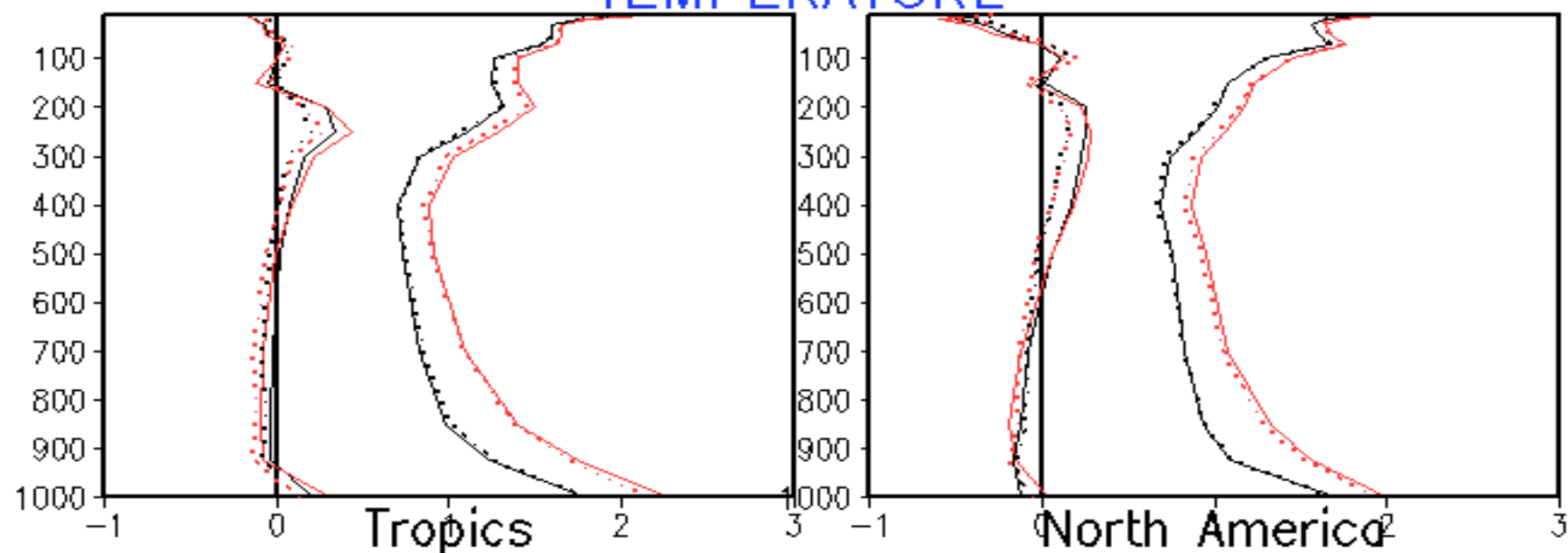
Upper troposphere/Stratosphere in Northern Hemisphere has increased RMSE



North

TEMPERATURE

South



gfs2015 solid pr4devbw13 dotted

Anl for 00z

Ges for 00z

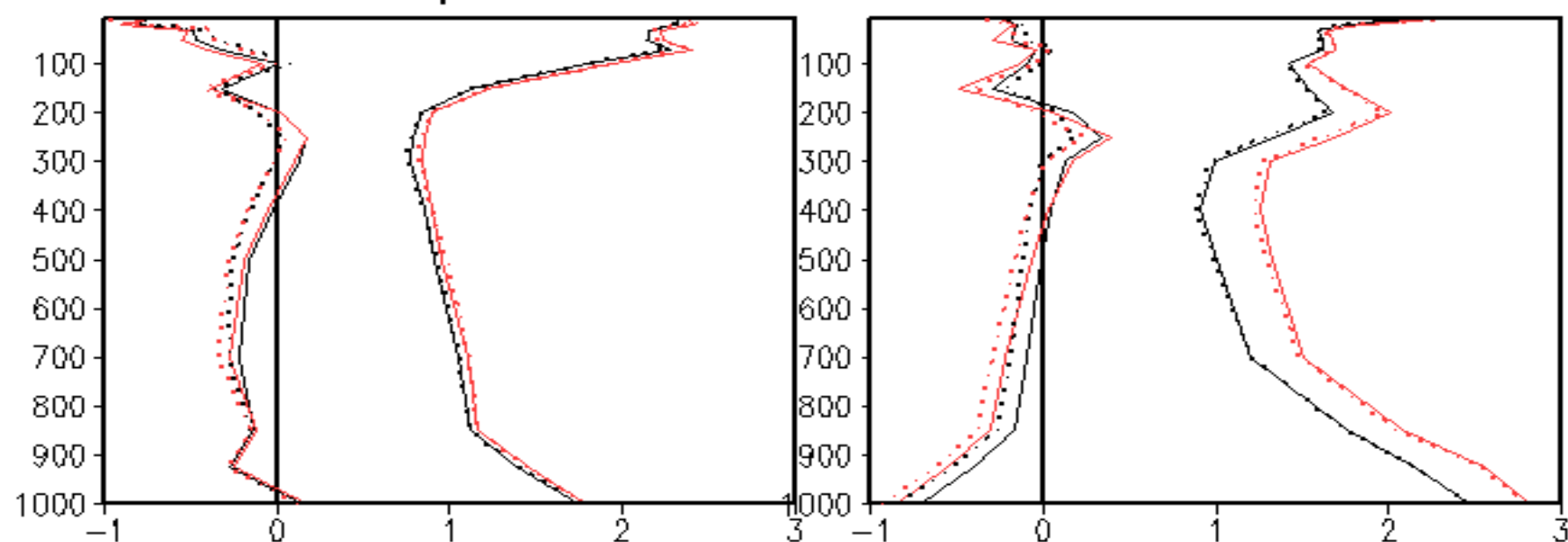
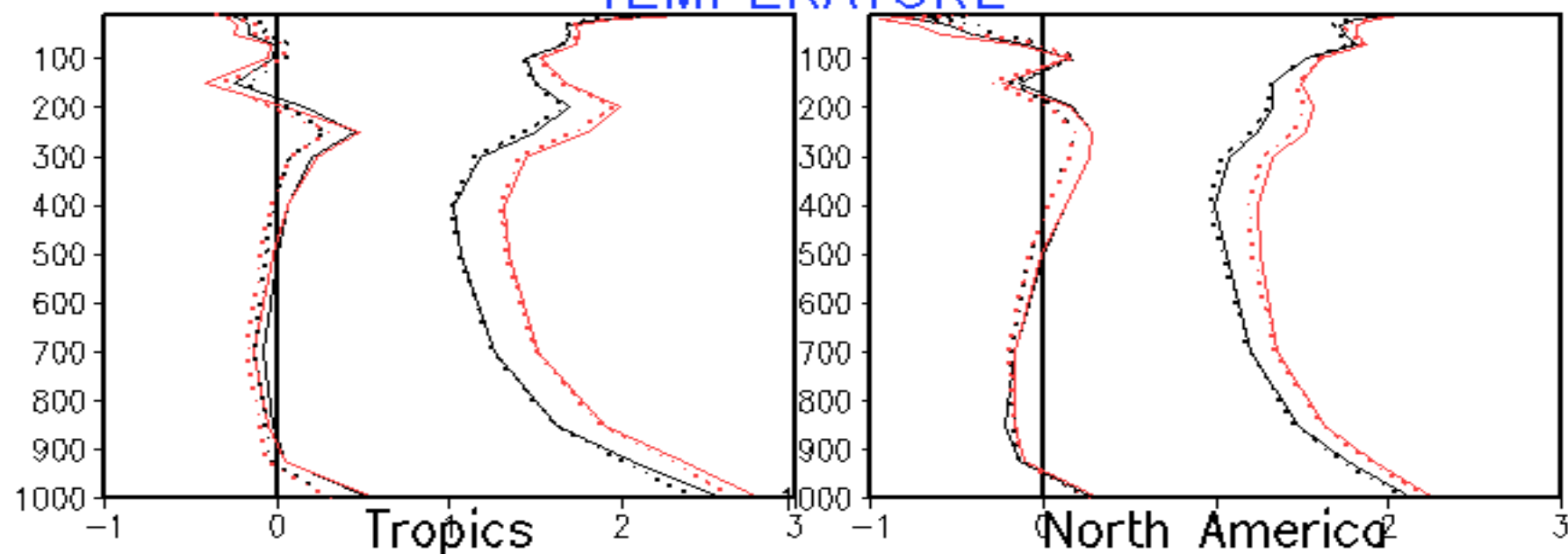
gfs2015 solid pr4devbw13 dotted

00z01dec2013 - 00z31may2014

North

TEMPERATURE

South



gfs2015 solid pr4devbw13 dotted

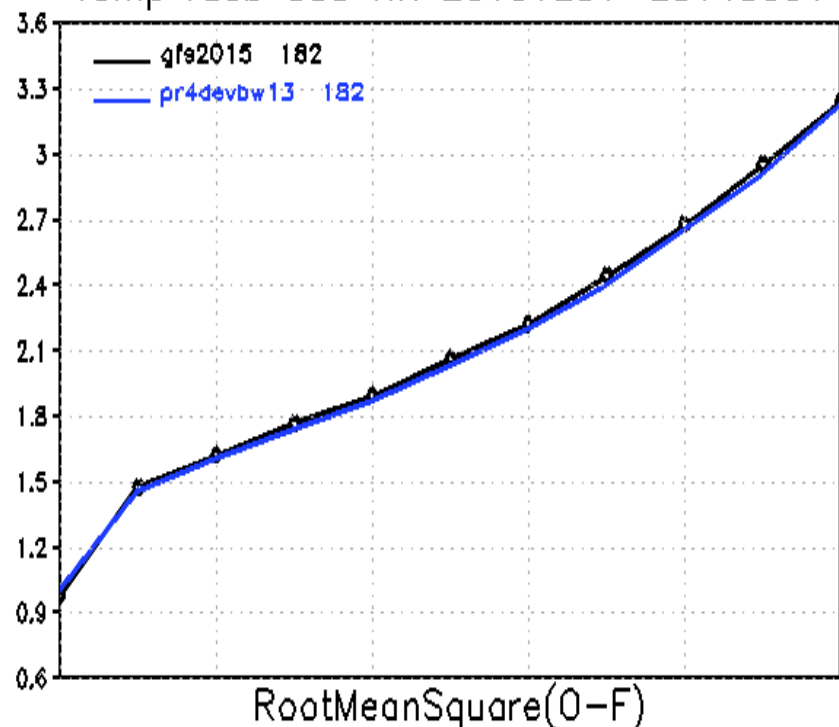
24-hr fcst

48-hr fcst

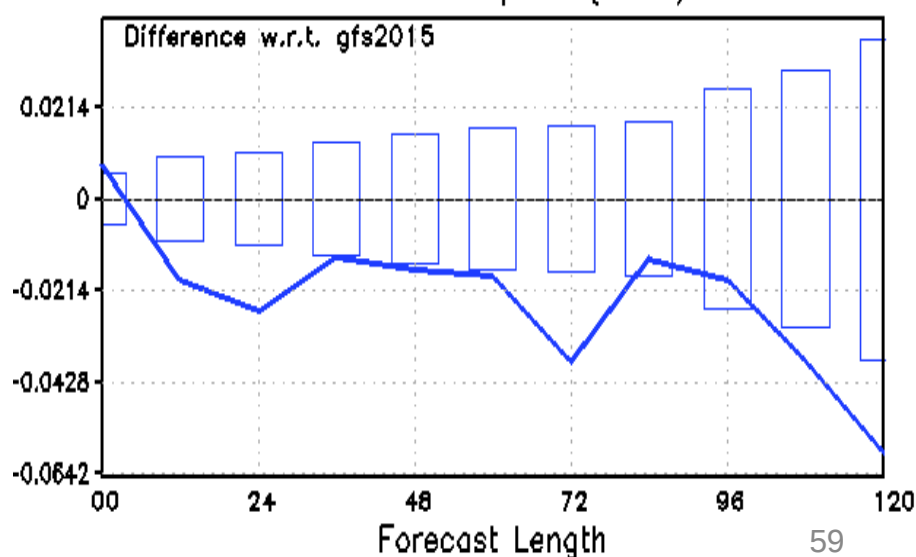
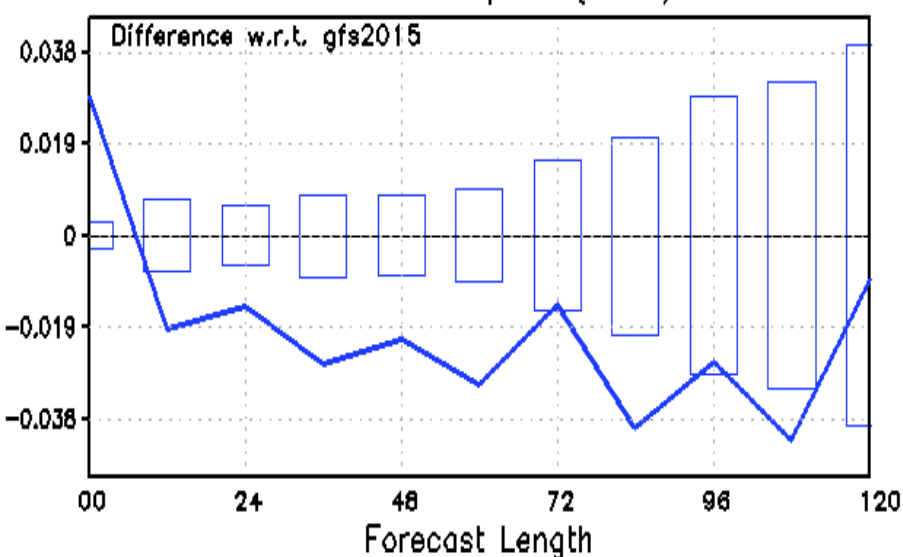
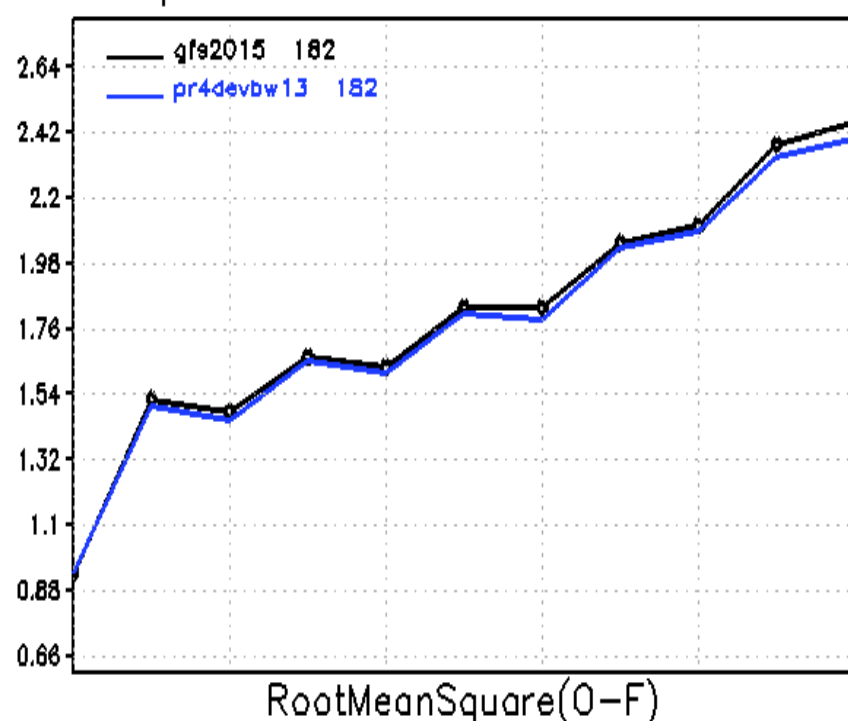
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00z01dec2013 - 00z31may2014

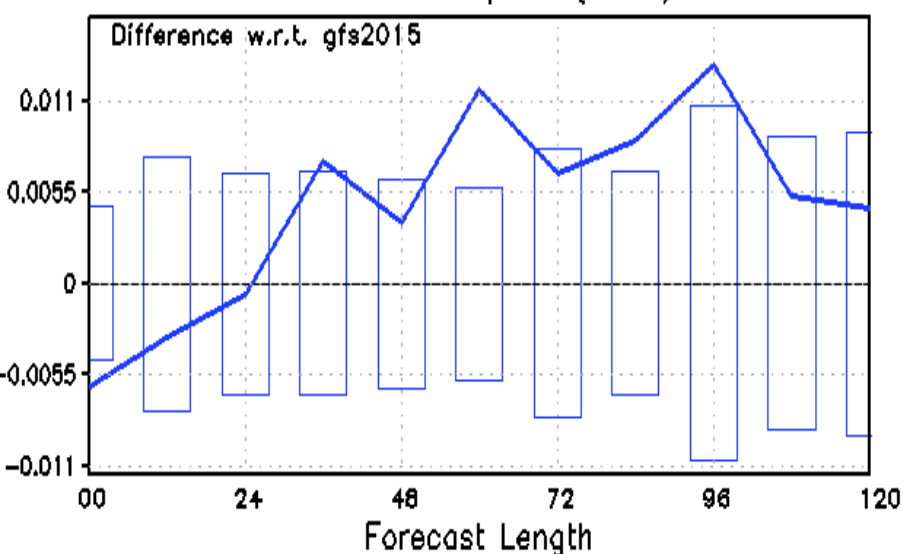
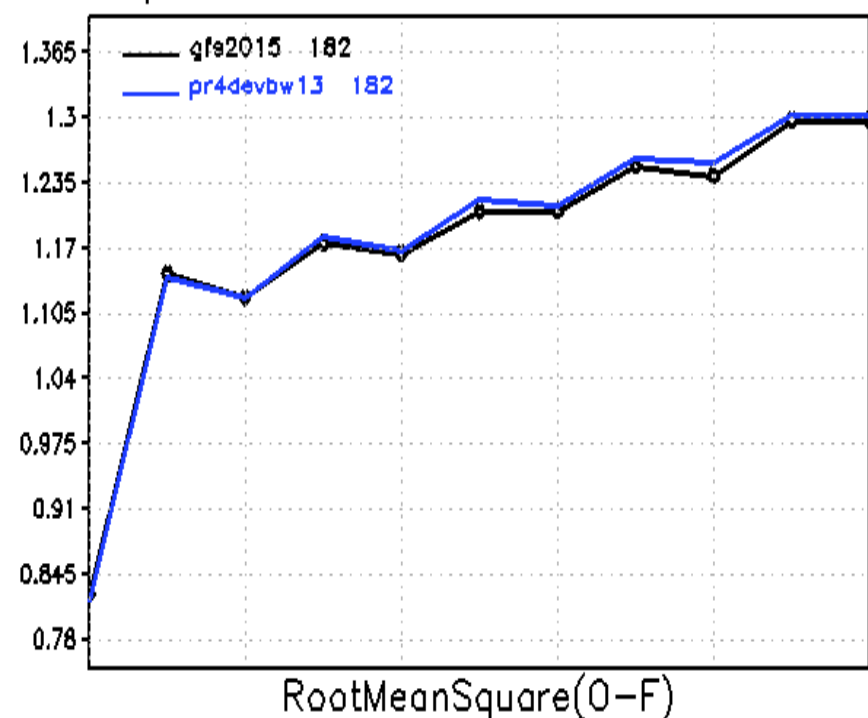
Temp raob 850 NH 20131201-20140531



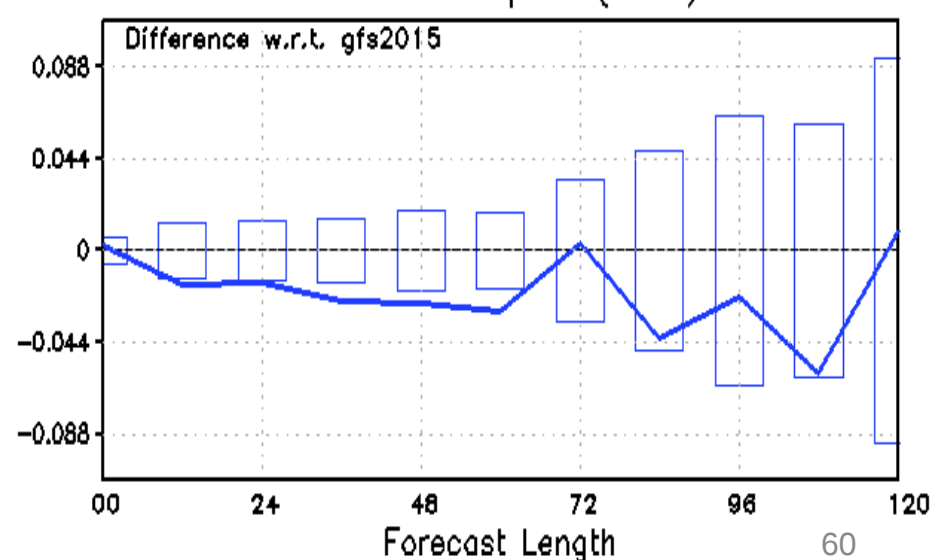
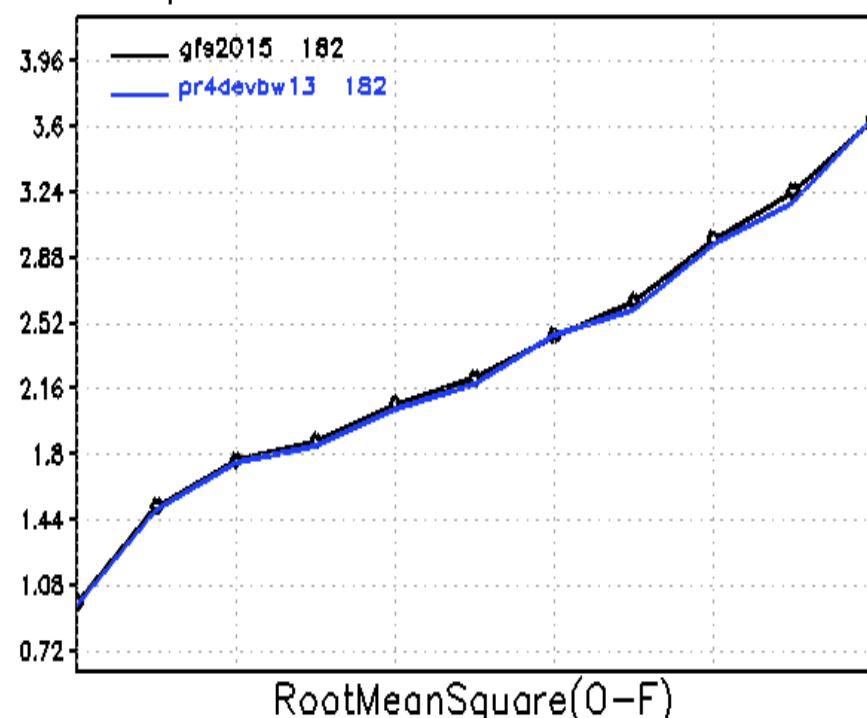
Temp raob 850 SH 20131201-20140531



Temp raob 850 TROPS 20131201-20140531



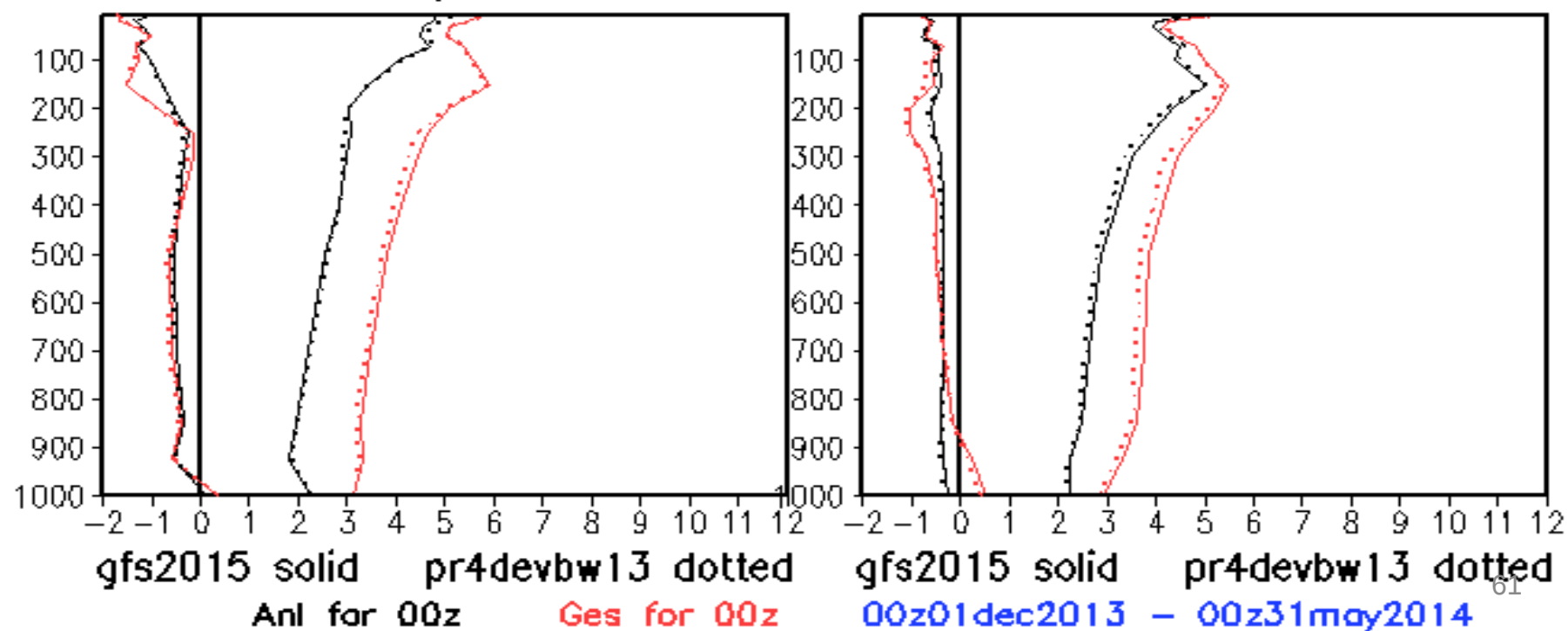
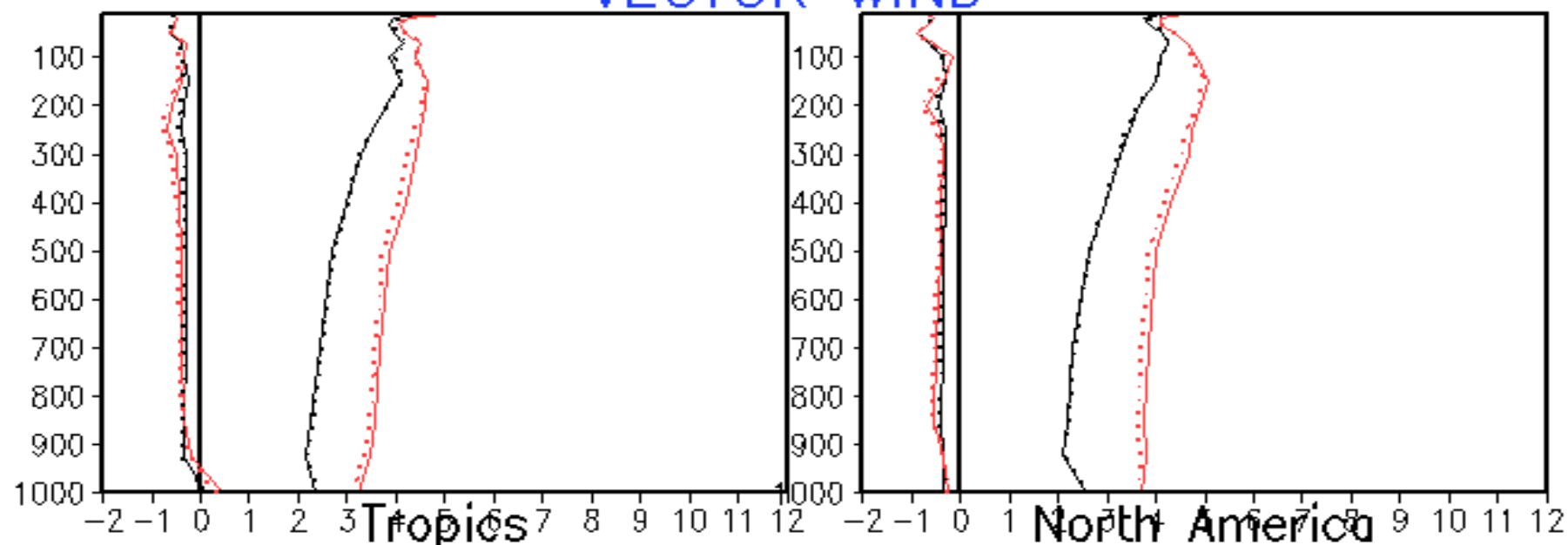
Temp raob 850 NA 20131201-20140531



North

VECTOR WIND

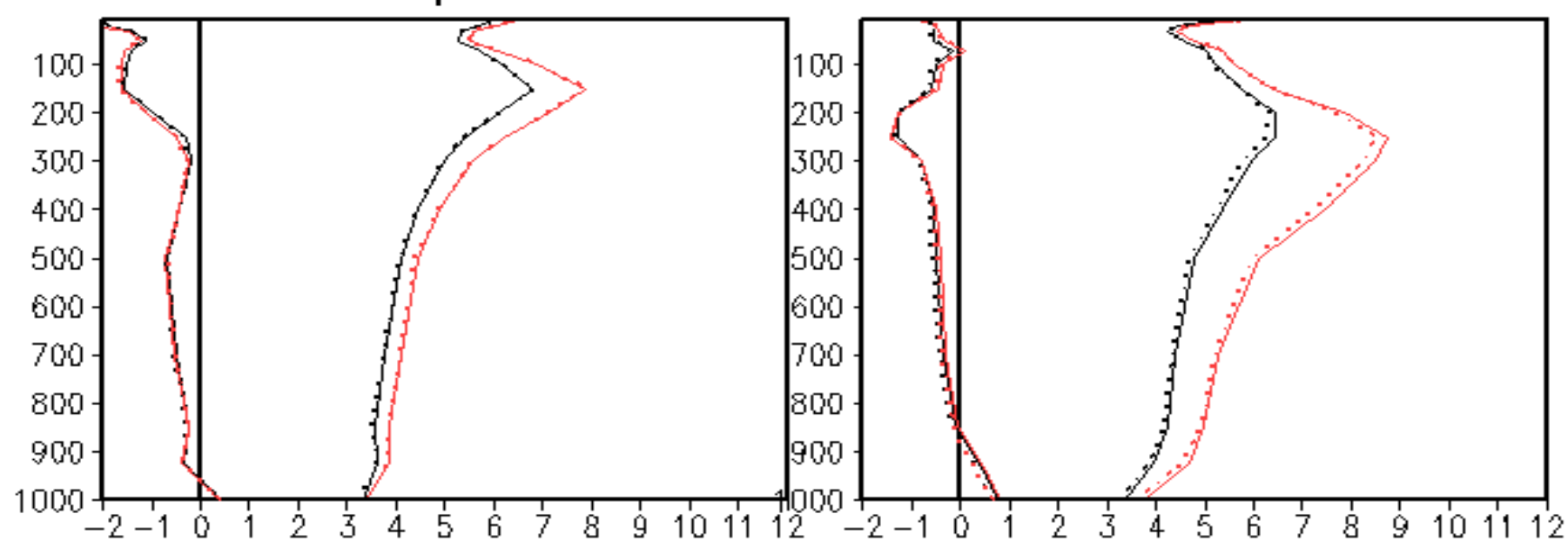
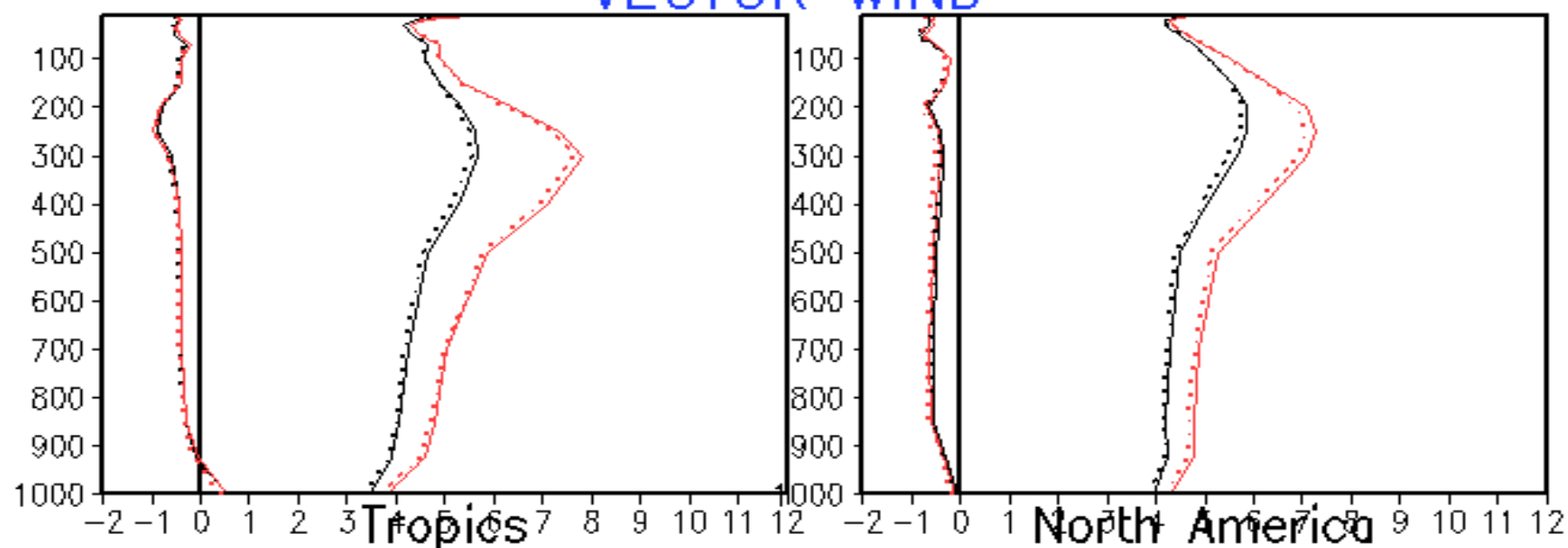
South



North

VECTOR WIND

South



gfs2015 solid pr4devbw13 dotted

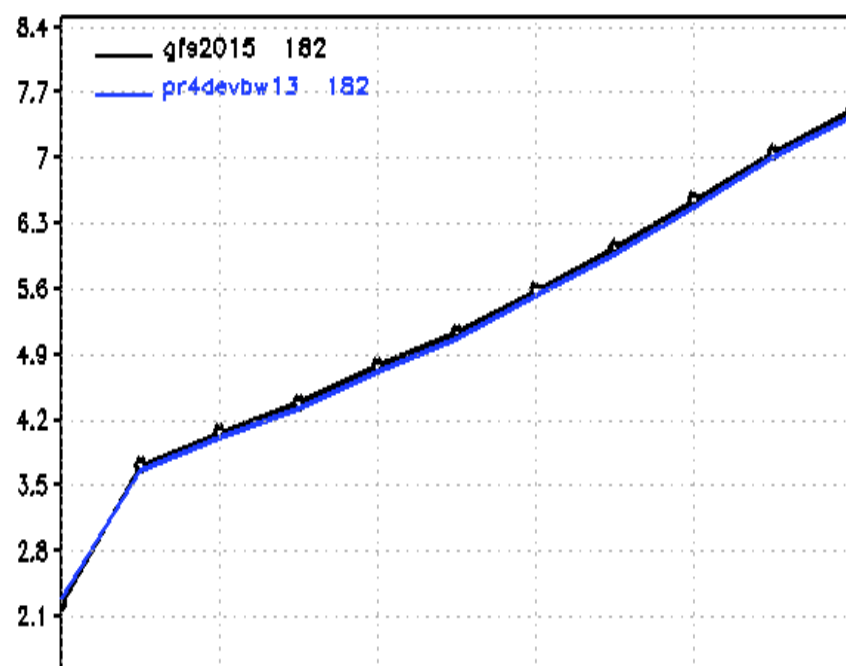
24-hr fcst

48-hr fcst

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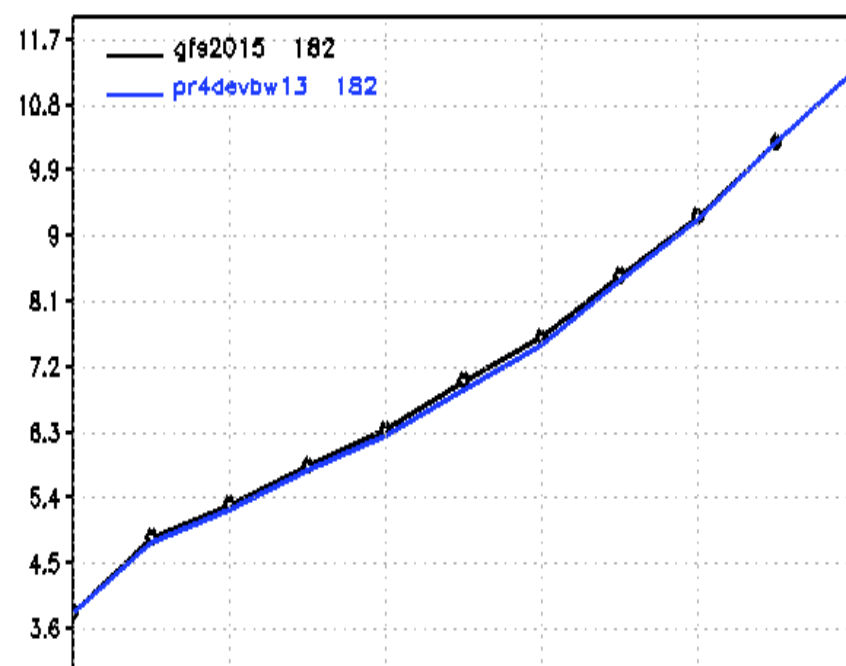
00z01dec2013 - 00z31may2014

Wind raob 850 NH 20131201-20140531

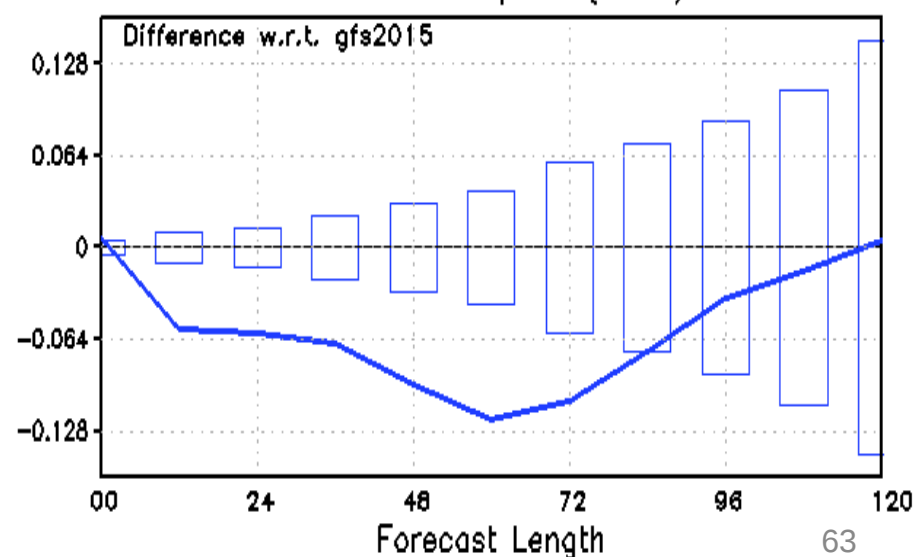
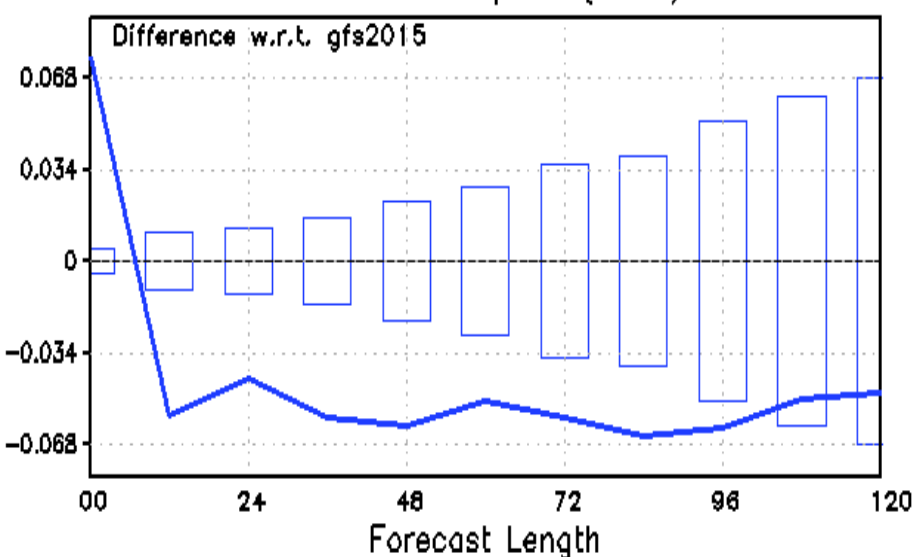


RootMeanSquare(0-F)

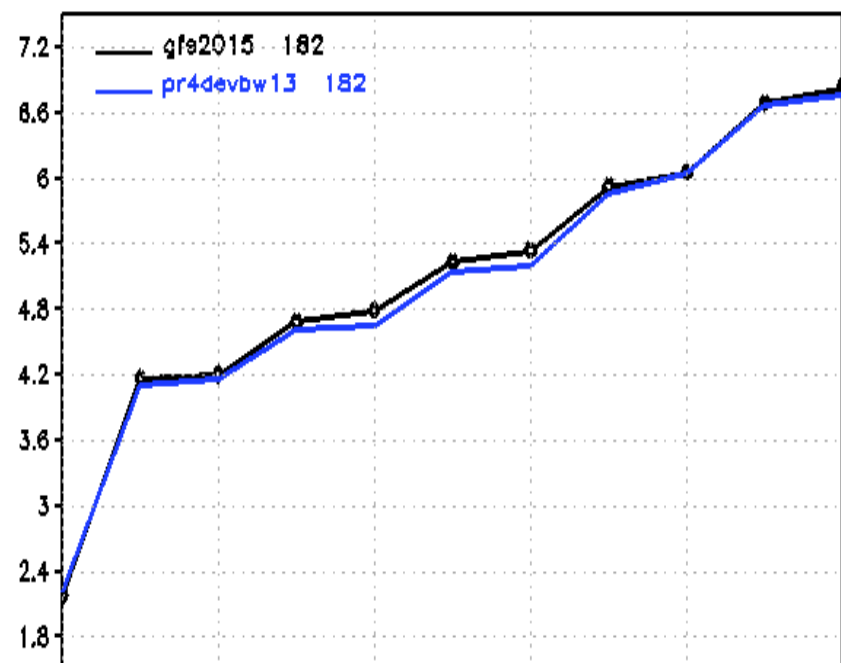
Wind raob 200 NH 20131201-20140531



RootMeanSquare(0-F)

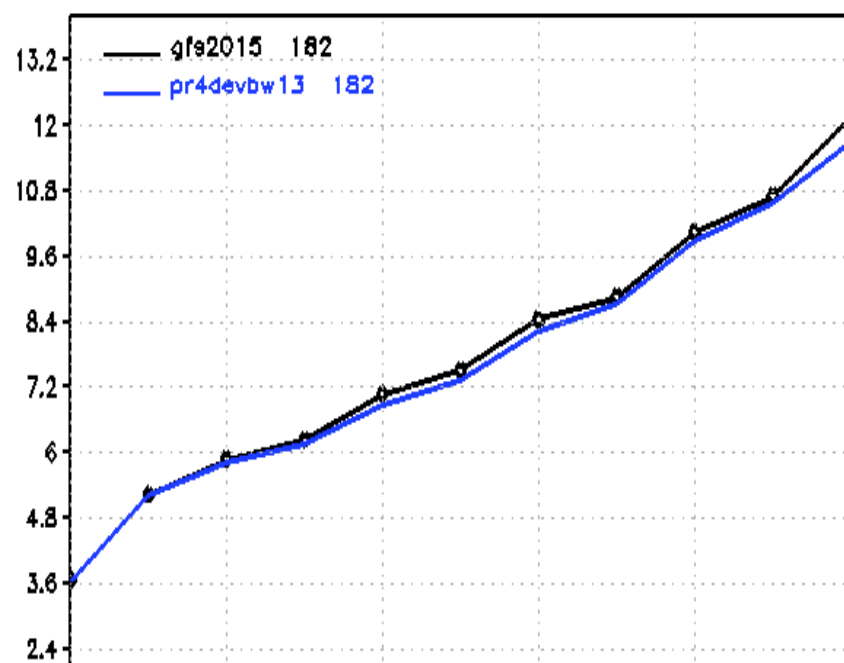


Wind raob 850 SH 20131201-20140531

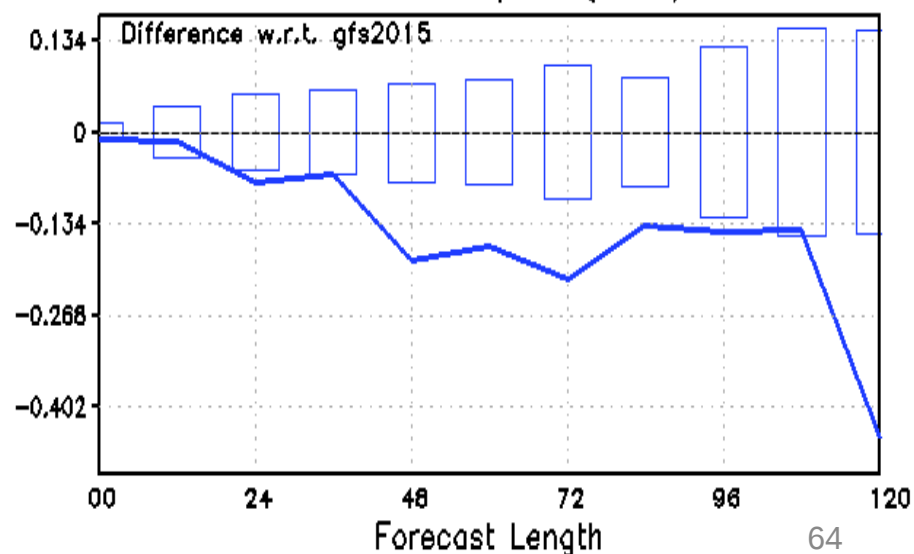
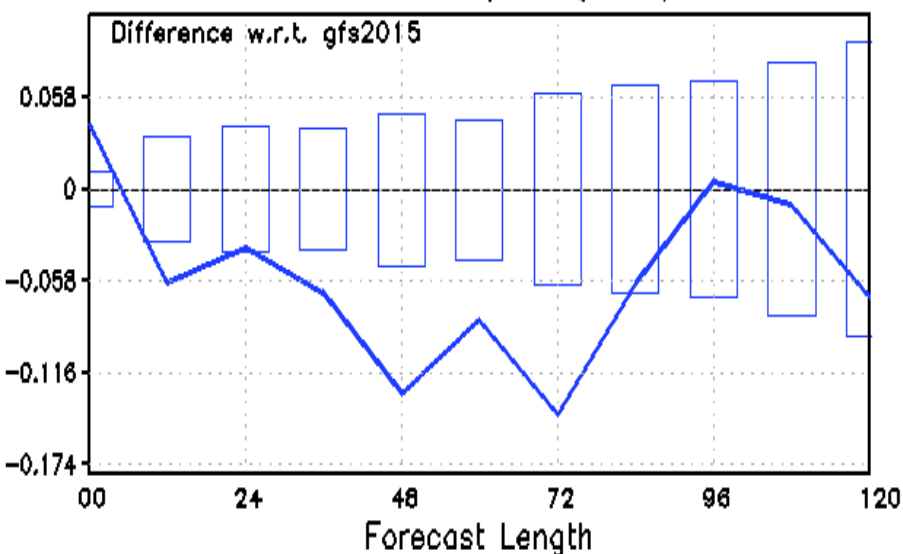


RootMeanSquare(0-F)

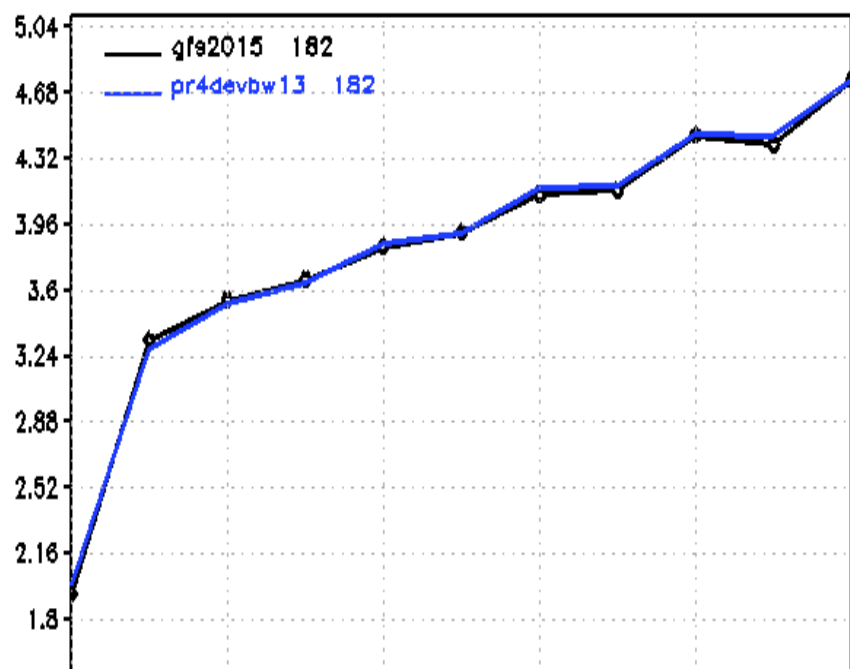
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RootMeanSquare(0-F)

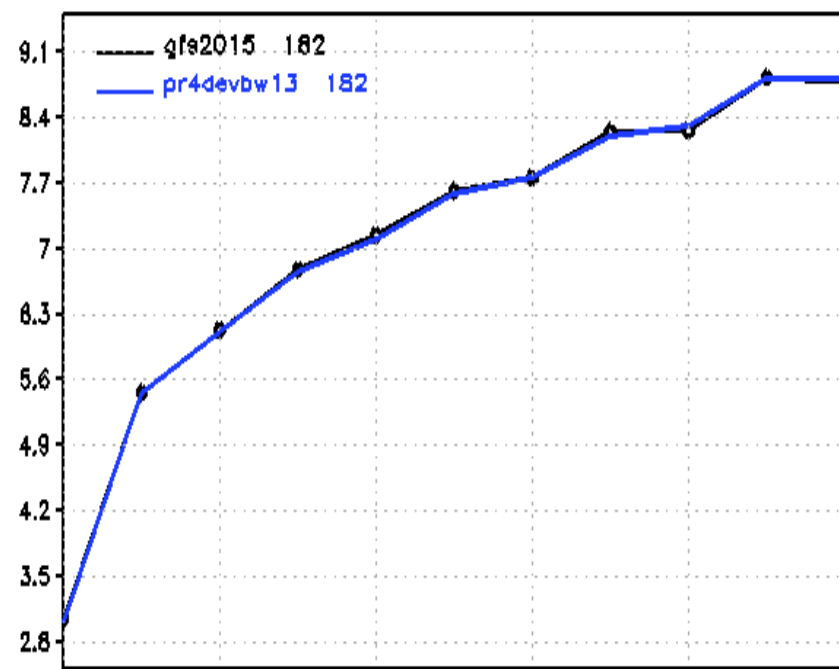


Wind raob 850 TROPS 20131201-20140531

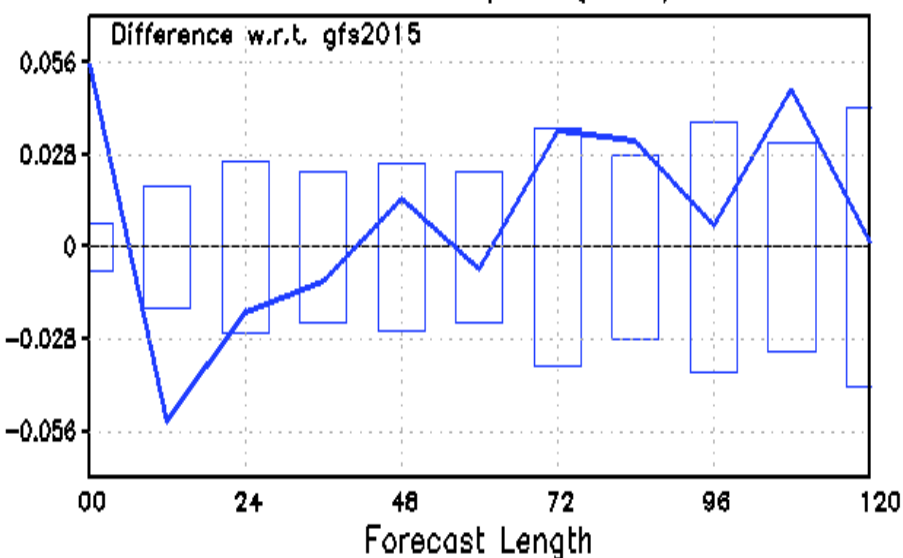


RootMeanSquare(0-F)

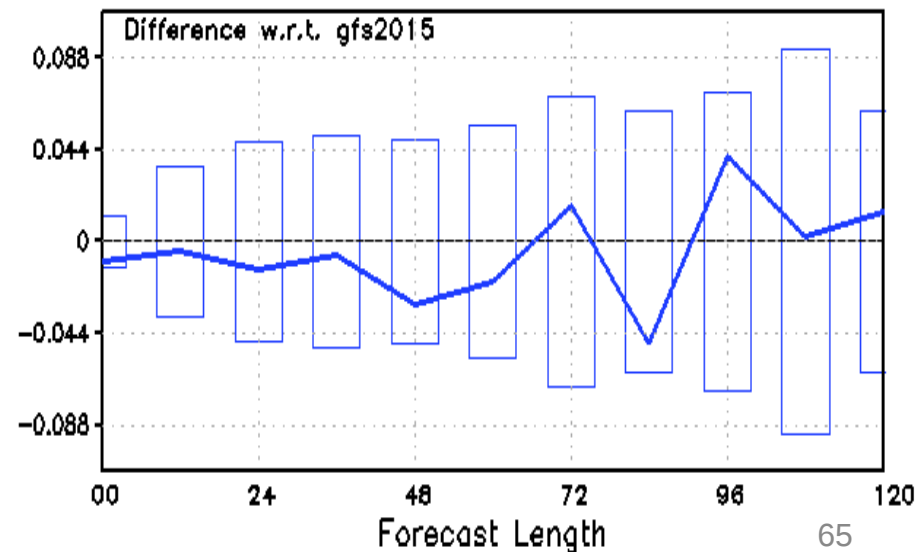
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RootMeanSquare(0-F)

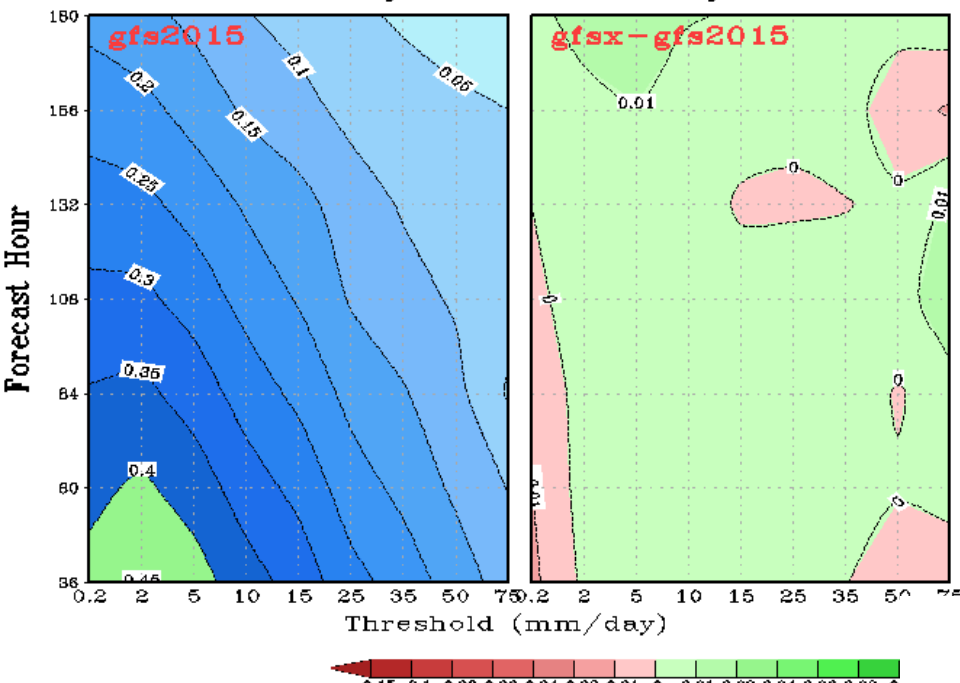


Forecast Length



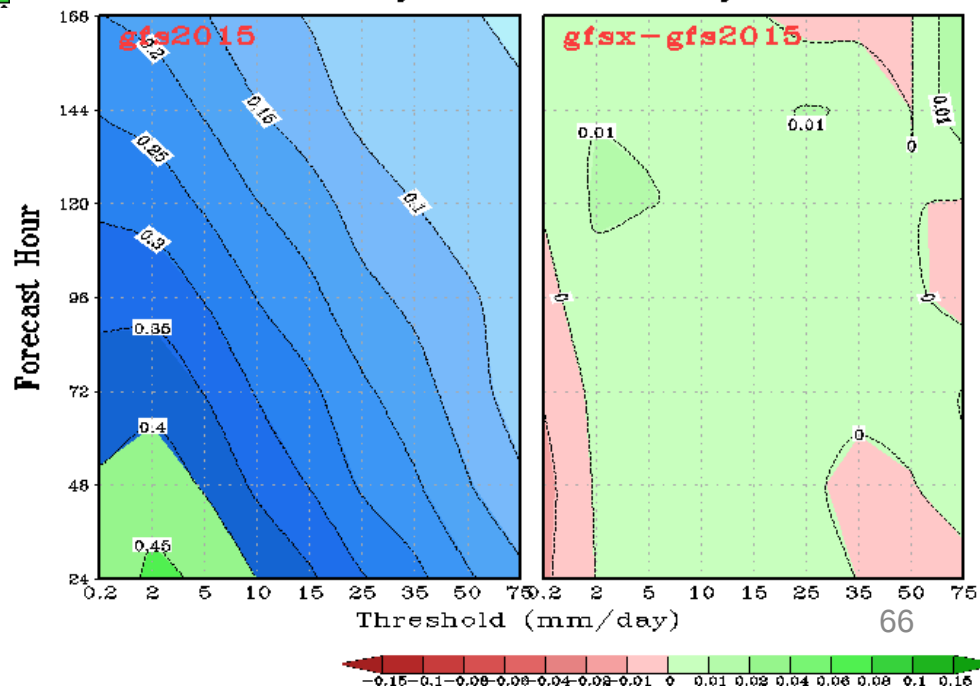
Forecast Length

CONUS Precipitation Equitable Threat Score  
01may2013-28feb2016 00Z Cycle

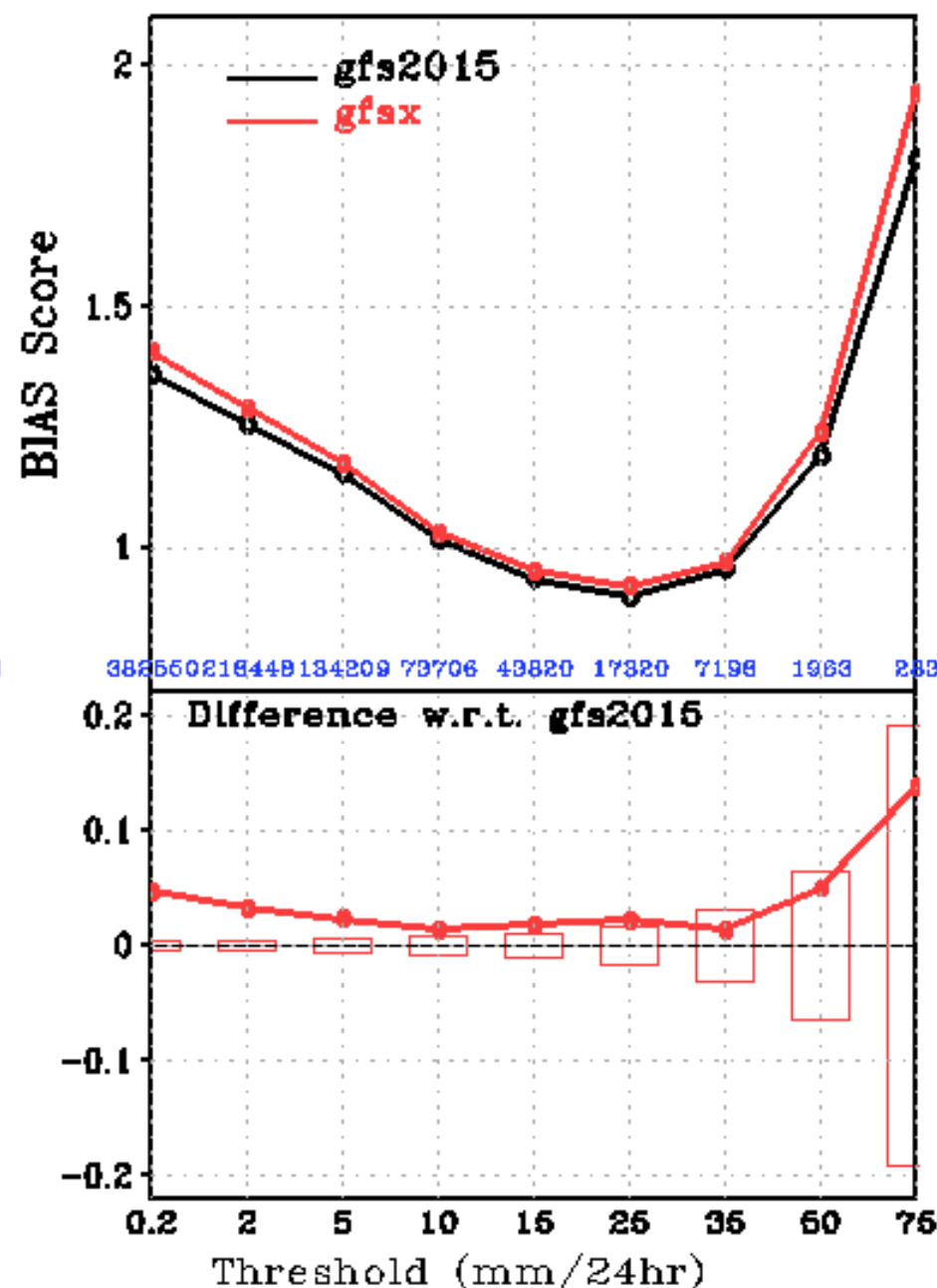
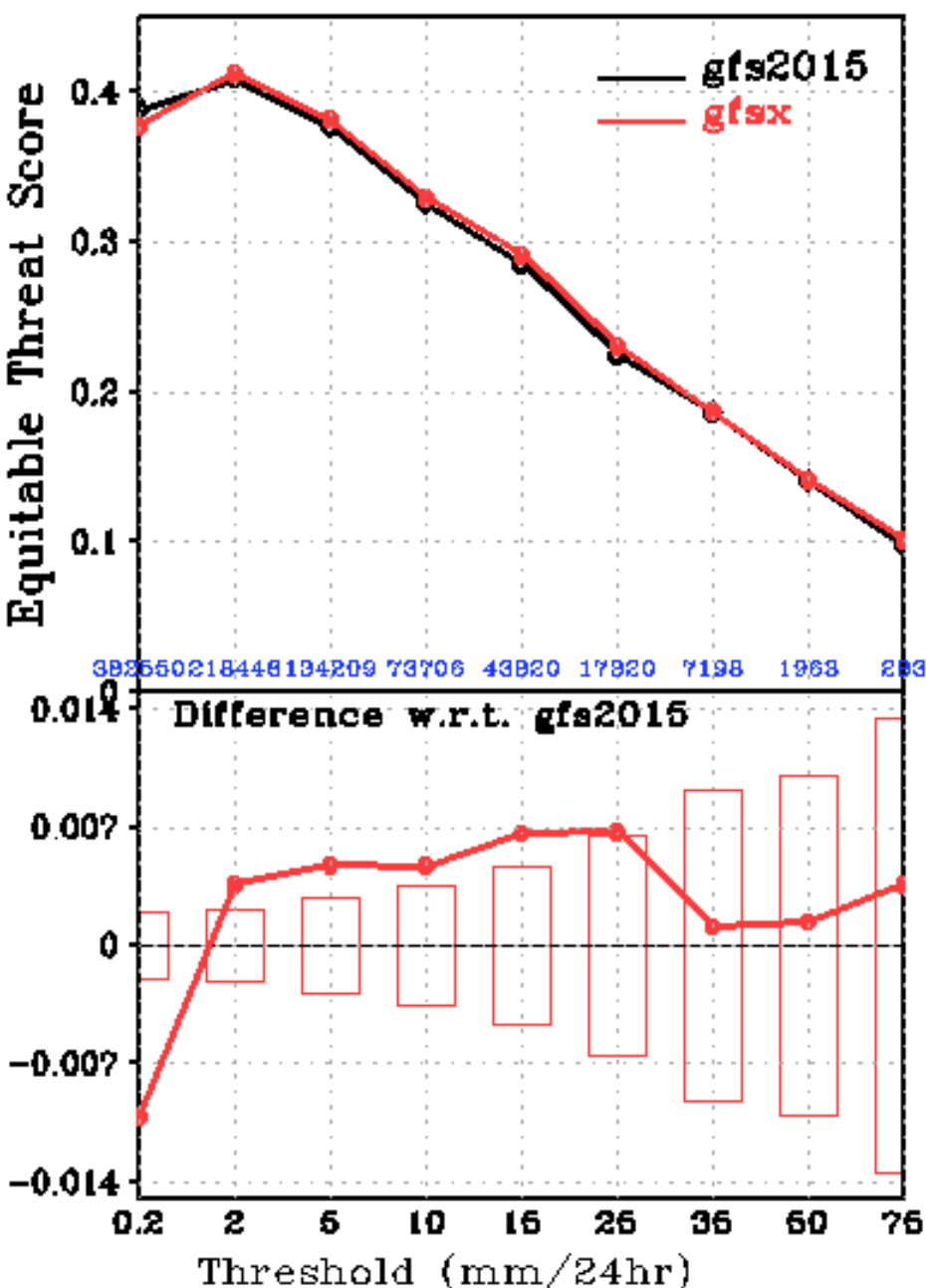


CONUS Precip ETS (00Z & 12Z)

CONUS Precipitation Equitable Threat Score  
01may2013-28feb2016 12Z Cycle



# CONUS Precip Skill Scores, f36-f60, 01may2013-28feb2016 00Z Cycle



Differences outside of the hollow bars are 95% significant based on 10000 Monte Carlo Tests

# **Equitable threat and bias scores for May 2013-February 2016 for CONUS**

**14 forecast lengths 00-24 hr to 156-180 hr for 00Z and 12Z forecasts**

**Nine Thresholds of 0.2 mm/day to 75 mm/day**

**GFSX forecasts for thresholds of 0.2 mm/day significantly worse for 0-24 to 84-108 h forecasts  
Worse wet bias for thresholds of 0.2 mm/day**

**GFSX forecasts for thresholds of 2, 5, 10 mm/day significantly better for 35/42 fcst lengths  
for thresholds of 15 mm/day significantly better 7/14 fcst lengths  
for thresholds of 25 mm/day significantly better 3/14 fcst lengths  
Slight tendency for less of dry bias 15-35 mm/day**

**Rain/no rain (Threshold of 0.2 mm/day) worse in GFSX**

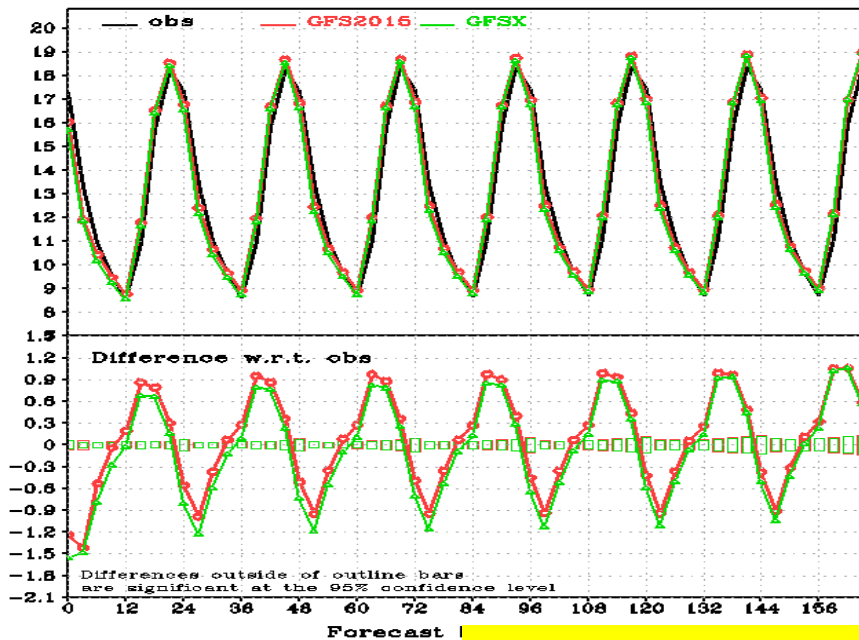
**Thresholds of 2 to 25 mm/day significantly improved**

*Verification of near surface fields  
against surface observations*

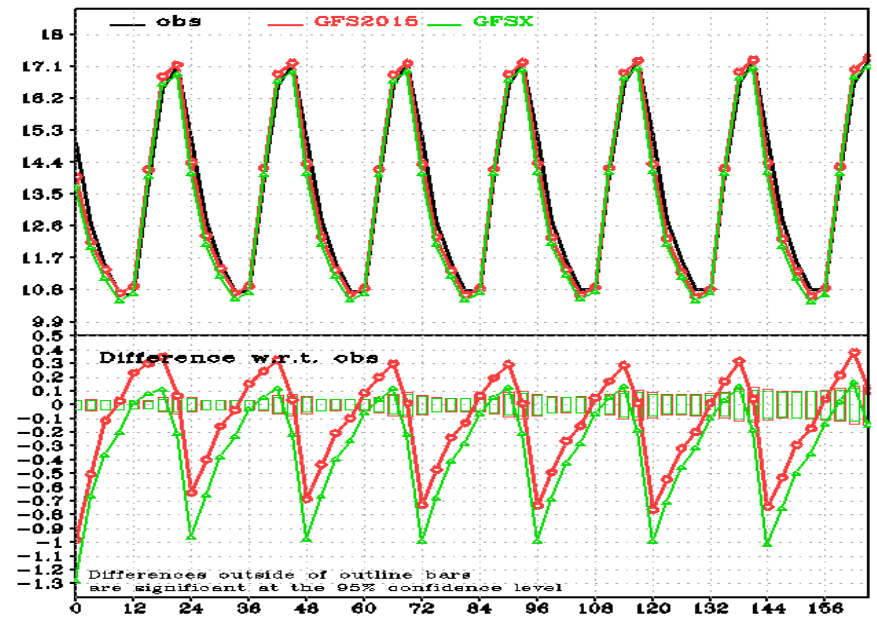
*CONUS (six regions, also west and east)  
and Alaska*

*Two years 0 and 12Z forecasts  
One year 6 and 18Z forecasts*

T SFC, CONUS West, 00Z Cycle, 20130501-20160118 Mean

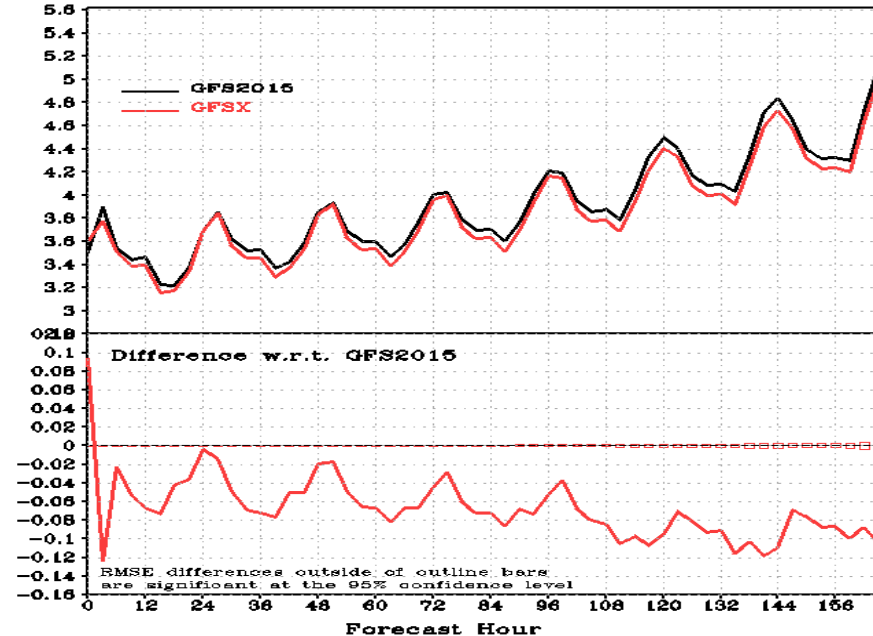


T SFC, CONUS East, 00Z Cycle, 20130501-20160118 Mean

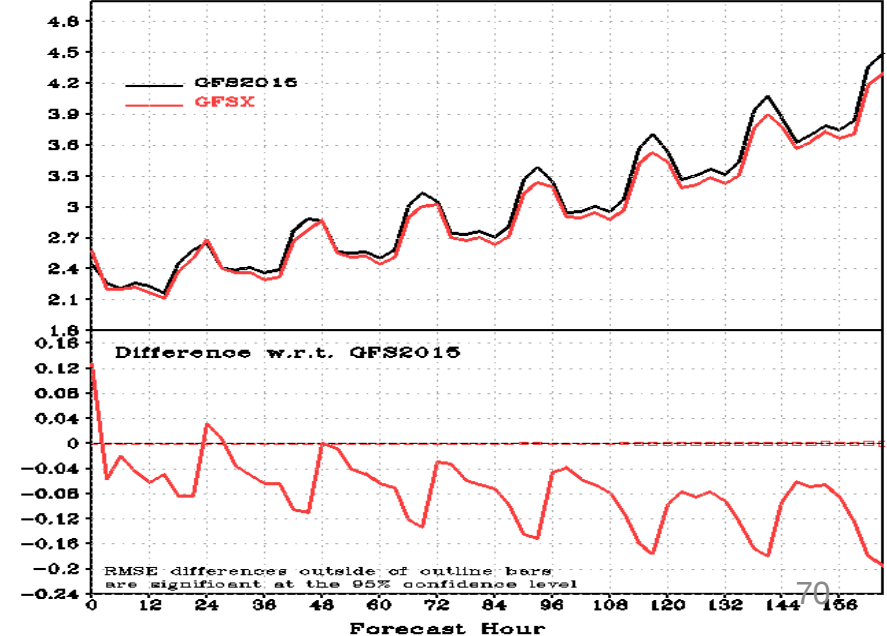


## Surface Temperature, CONUS West and East, 00Z Cycle

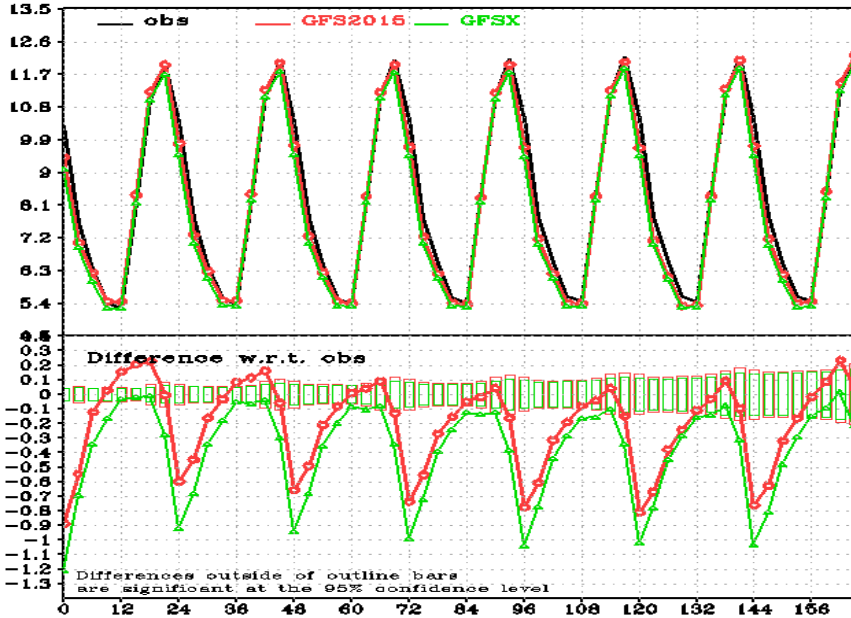
RMS: T SFC, CONUS West, 00Z cyc, 20130501-20160118



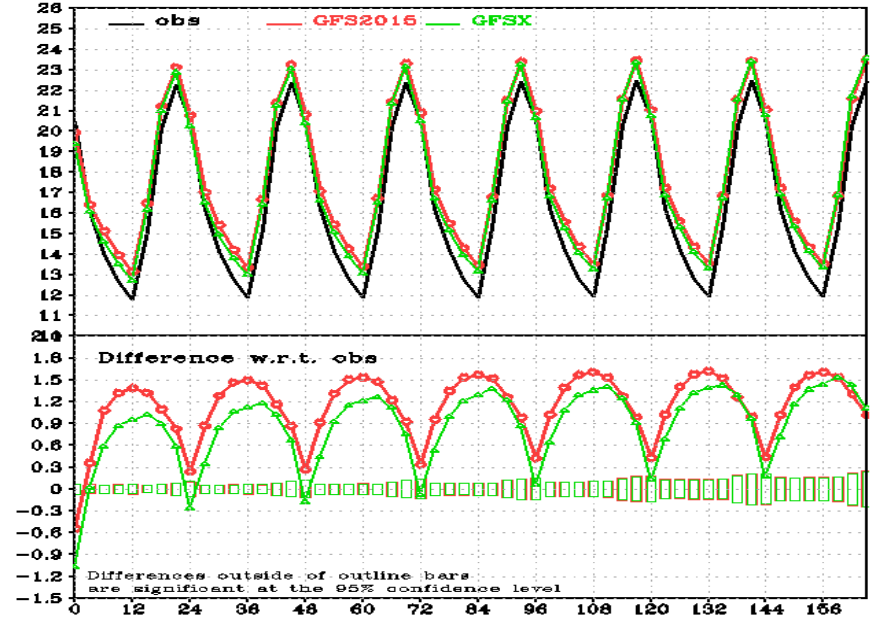
RMS: T SFC, CONUS East, 00Z cyc, 20130501-20160118



T SFC, N. Plains and Mid-West, 00Z Cycle, 20130501-20160118 Mean



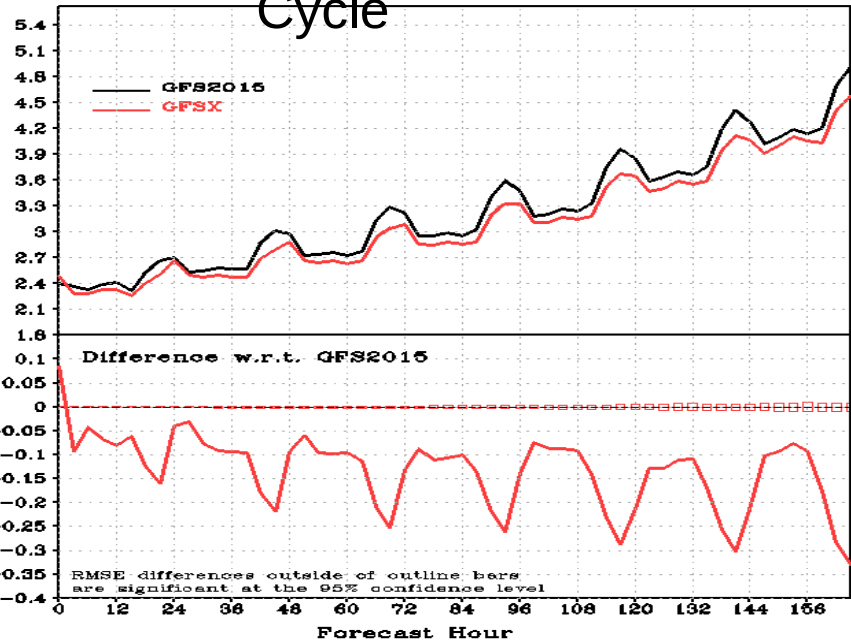
T SFC, S. Plains, 00Z Cycle, 20130501-20160118 Mean



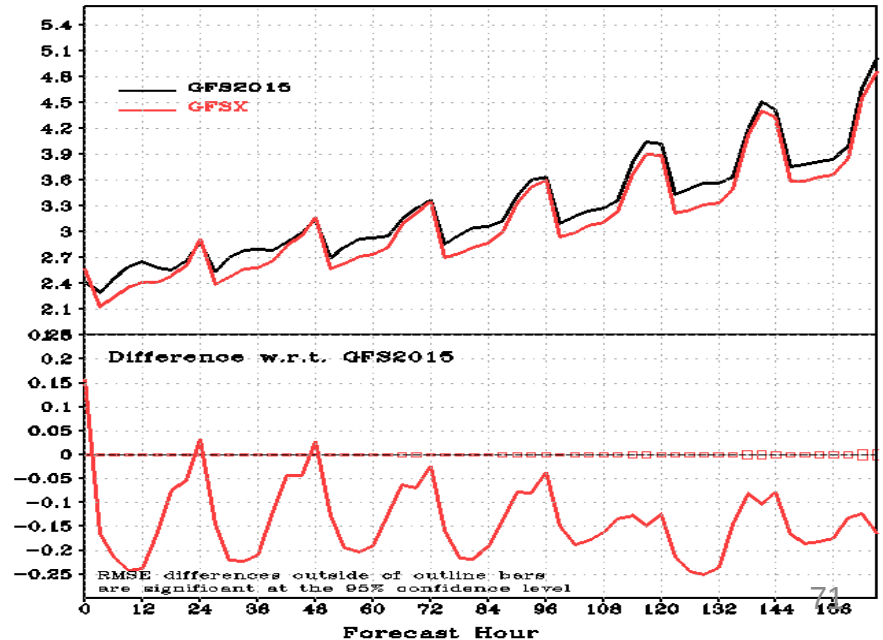
## Surface Temperature, N. Plains and Mid-West, S. Plains 00Z

RMS: T SFC, N. Plains and Mid-West, 00Z cyc, 20130501-20160118

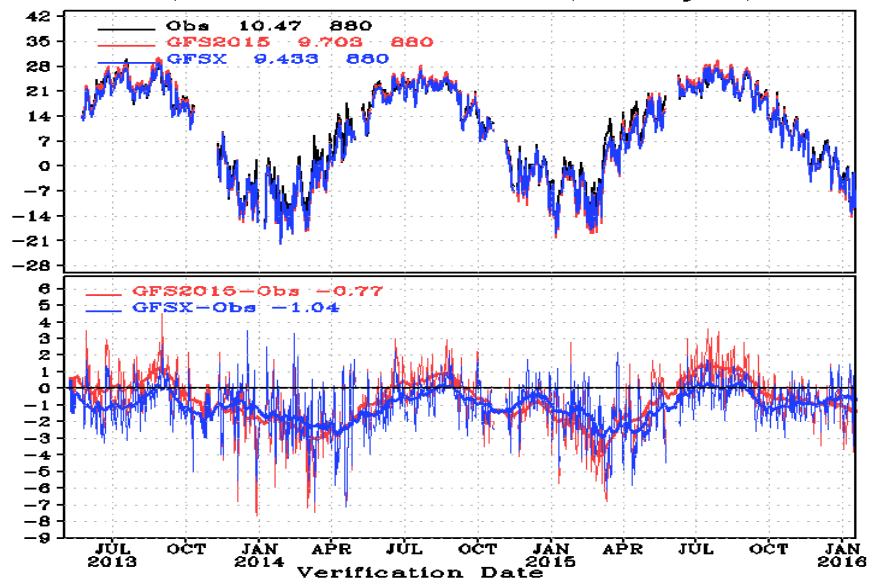
Cycle



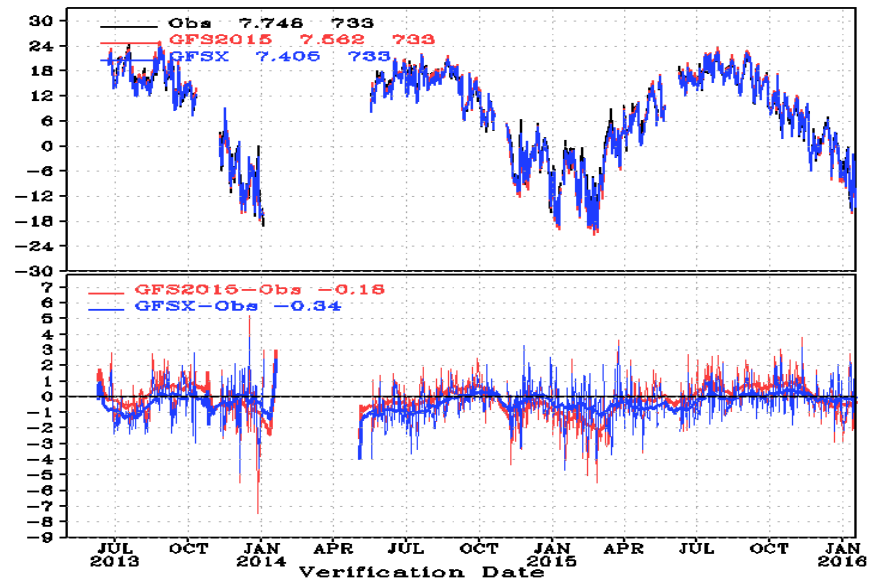
RMS: T SFC, S. Plains, 00Z cyc, 20130501-20160118



T SFC, N. Plains and Mid-West, 00Z cycle, fh96

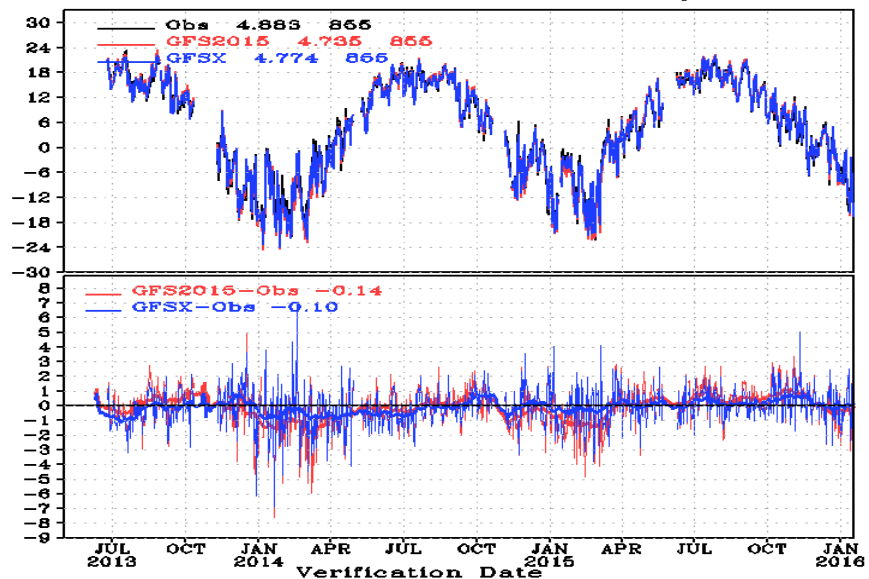


T SFC, N. Plains and Mid-West, 06Z cycle, fh96

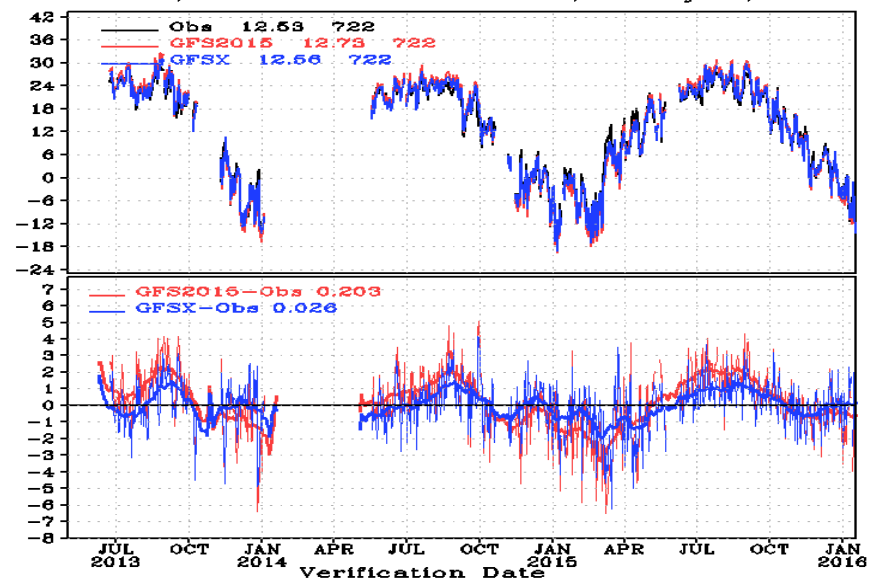


## Surface Temperature, N. Plains and Mid-West, All four cycles

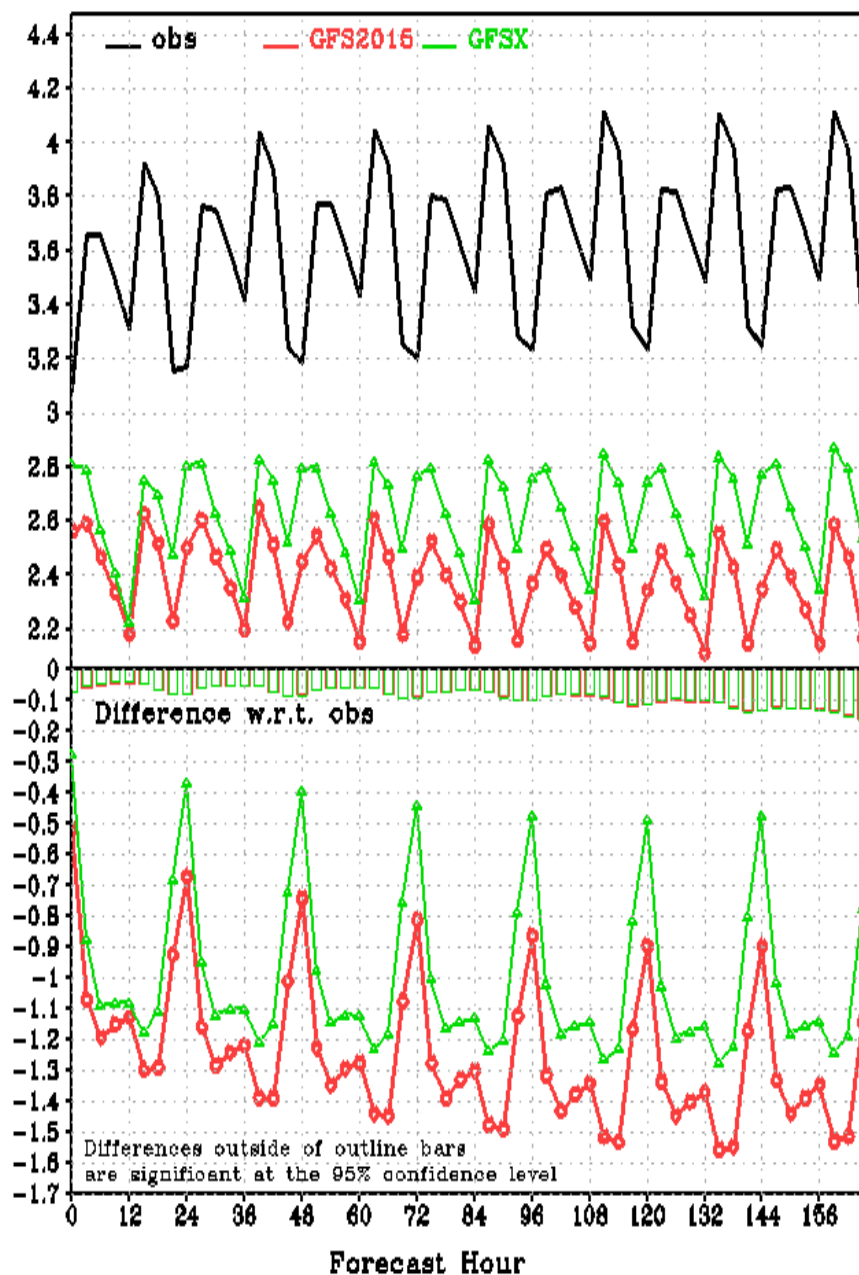
T SFC, N. Plains and Mid-West, 12Z cycle, fh96



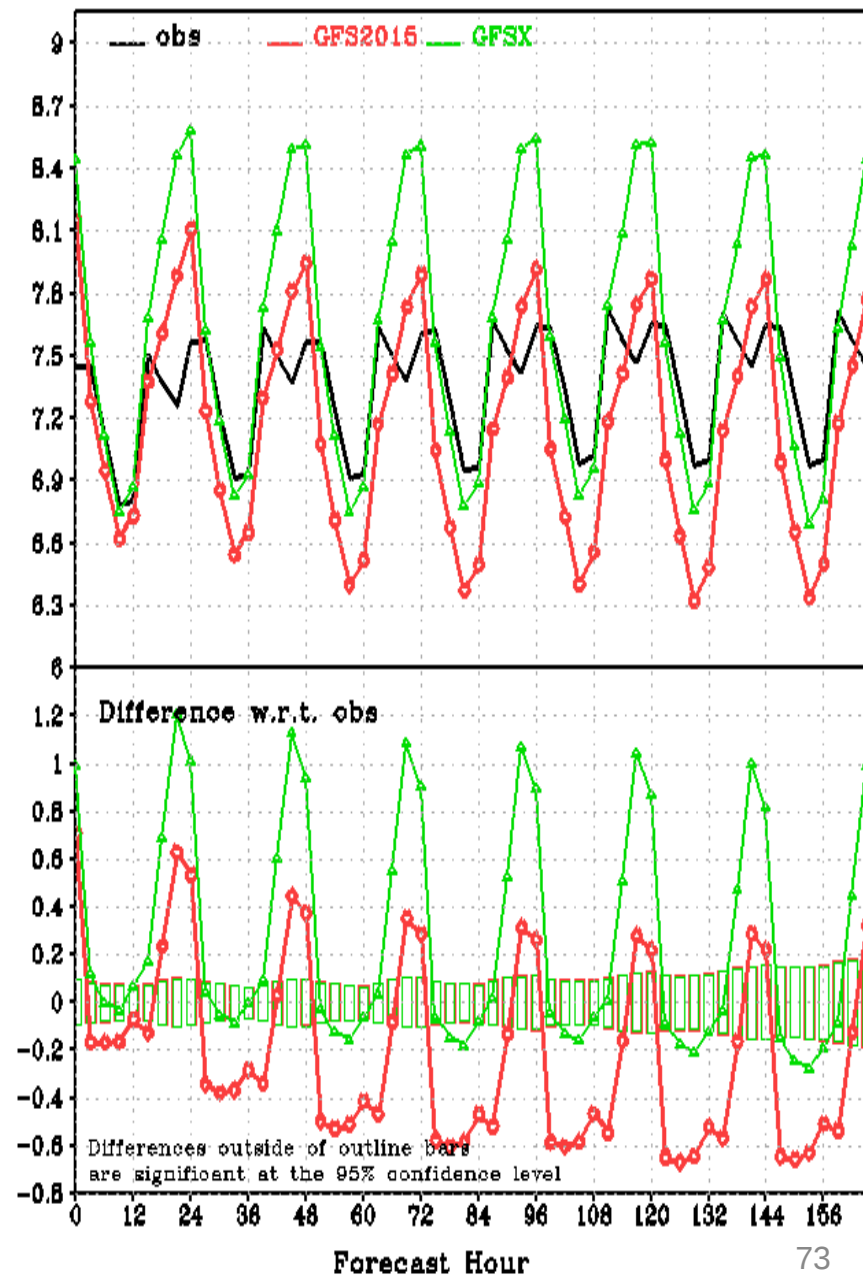
T SFC, N. Plains and Mid-West, 18Z cycle, fh96



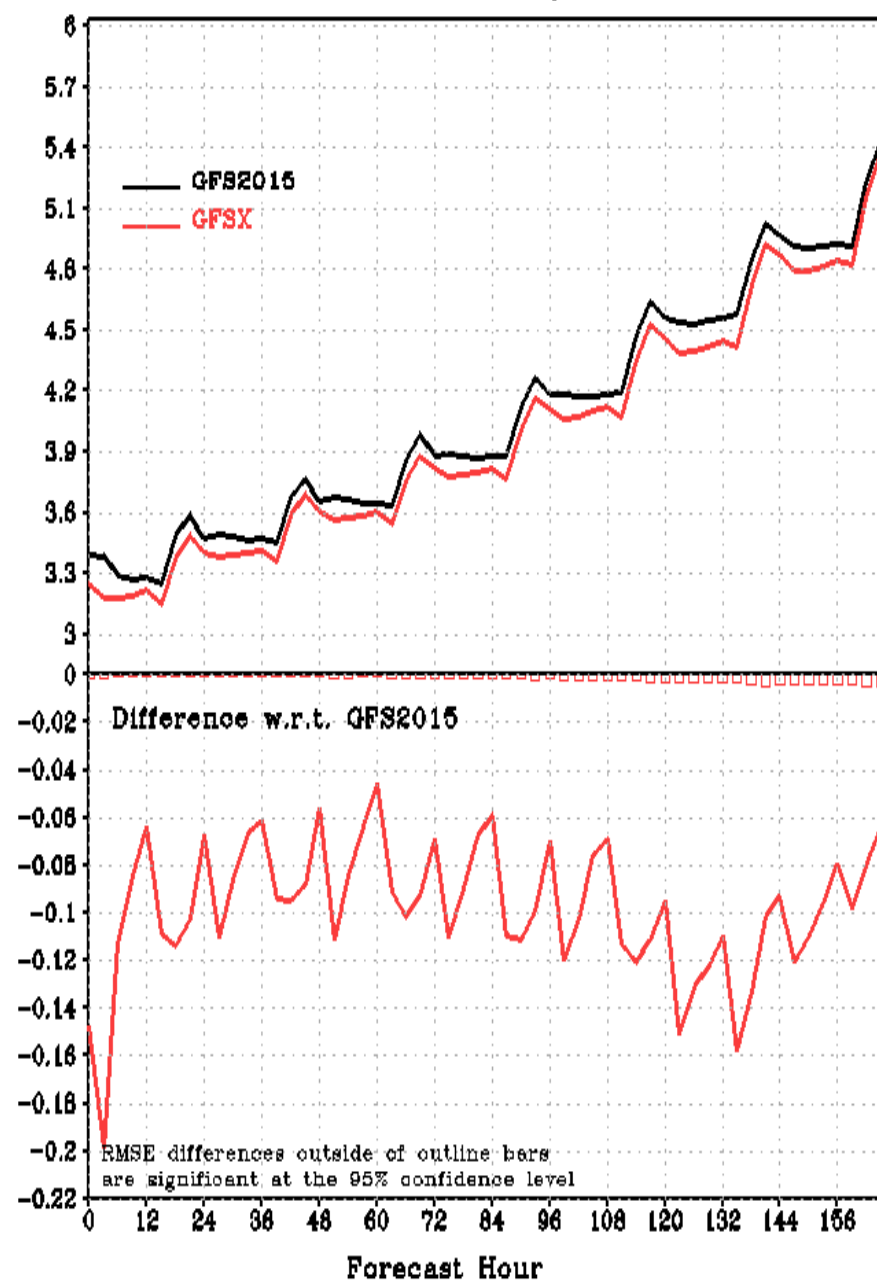
DPT SFC, CONUS West, 00Z Cycle, 20140101-20151231 Mean



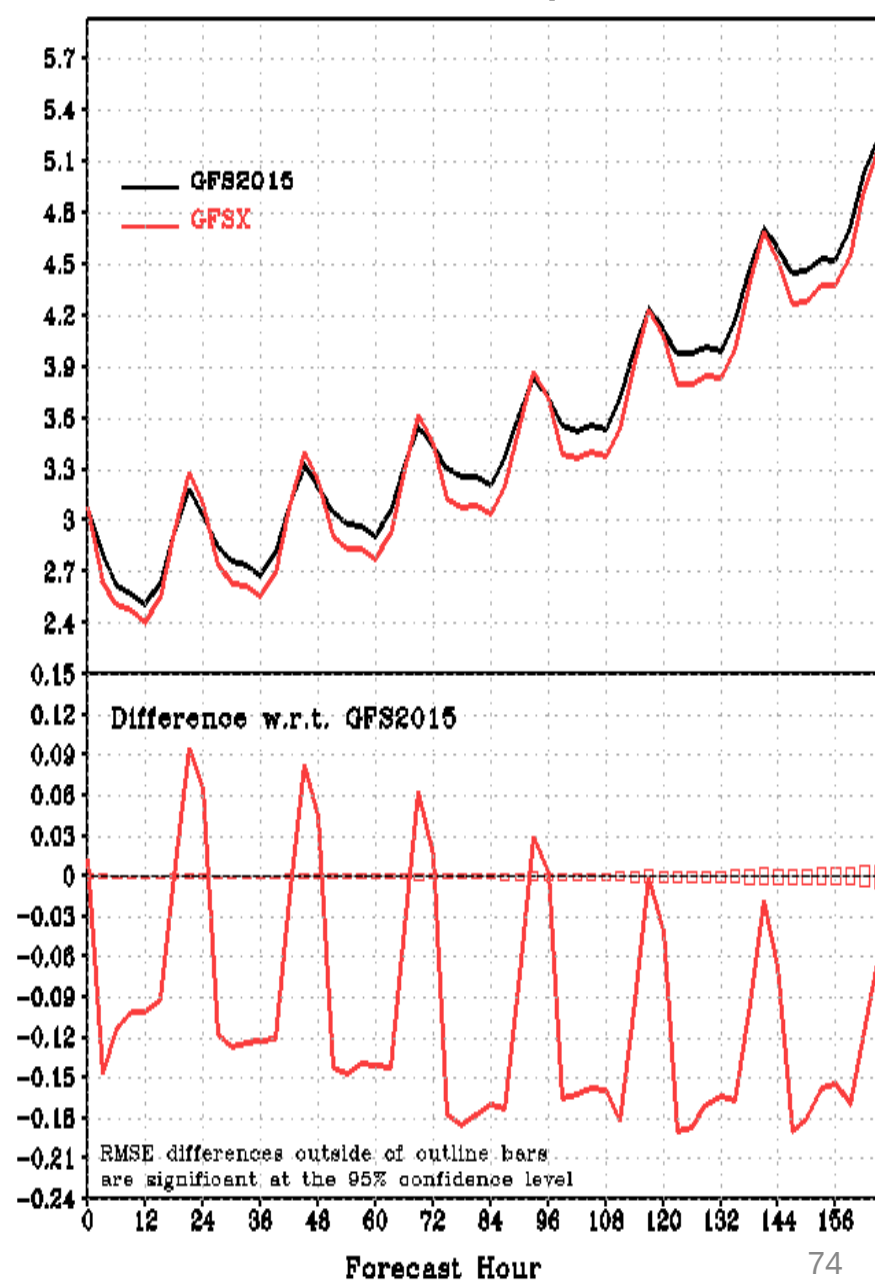
DPT SFC, CONUS East, 00Z Cycle, 20140101-20151231 Mean



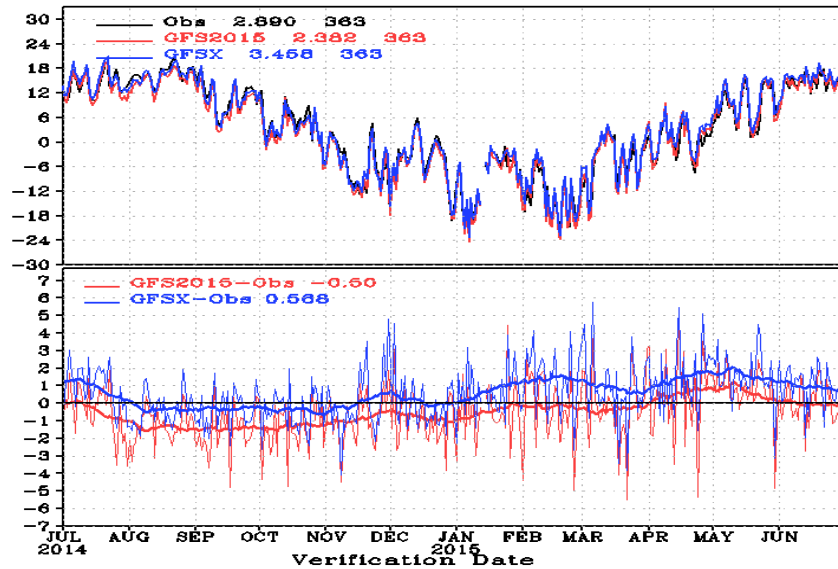
RMS: DPT SFC, CONUS West, 00Z cye, 20140101-20151231



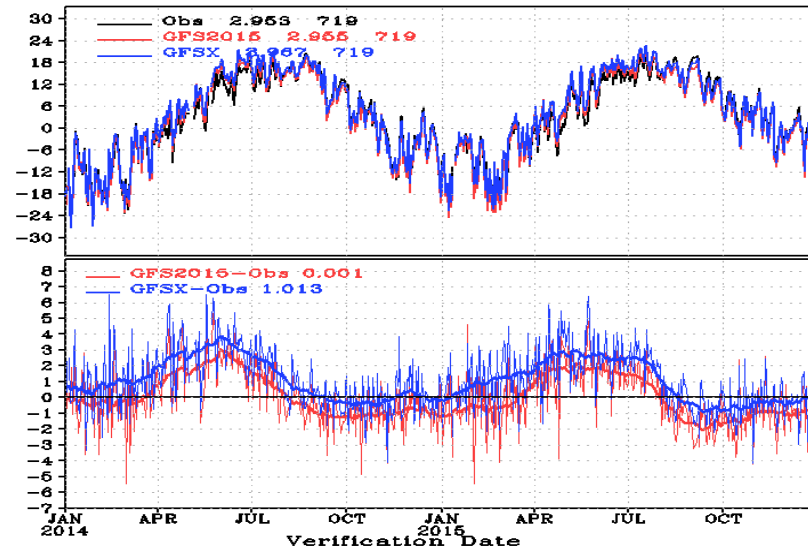
RMS: DPT SFC, CONUS East, 00Z cye, 20140101-20151231



DPT SFC, N. Plains and Mid-West, 16Z cycle, fh96

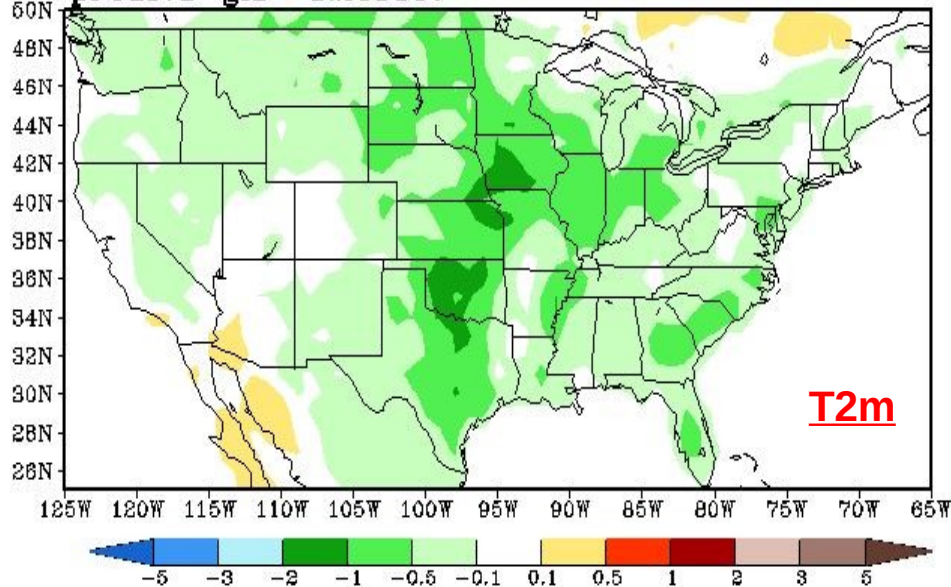


DPT SFC, N. Plains and Mid-West, 00Z cycle, fh96

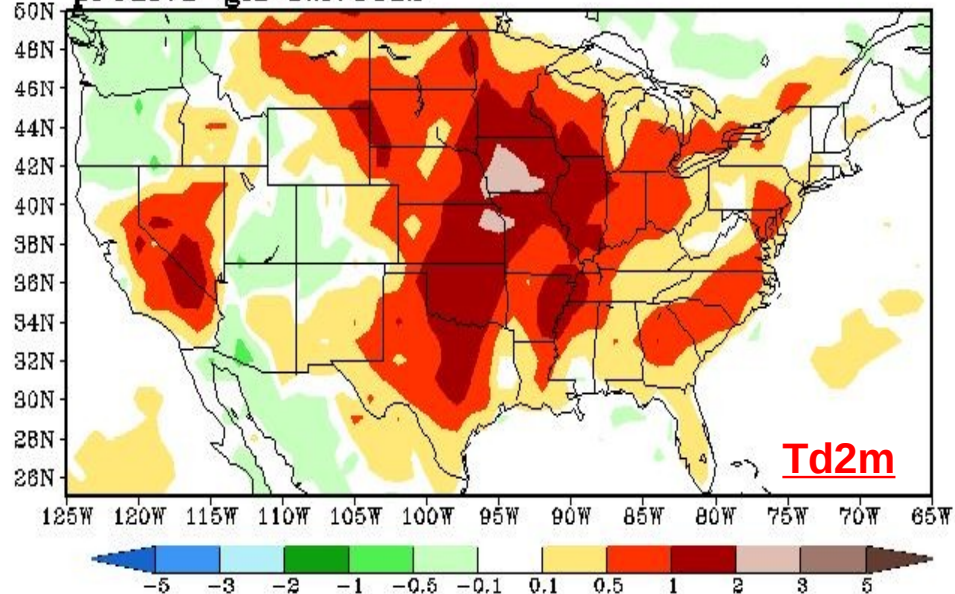


# Significantly improve the biases brought up in the EMC MEG meeting

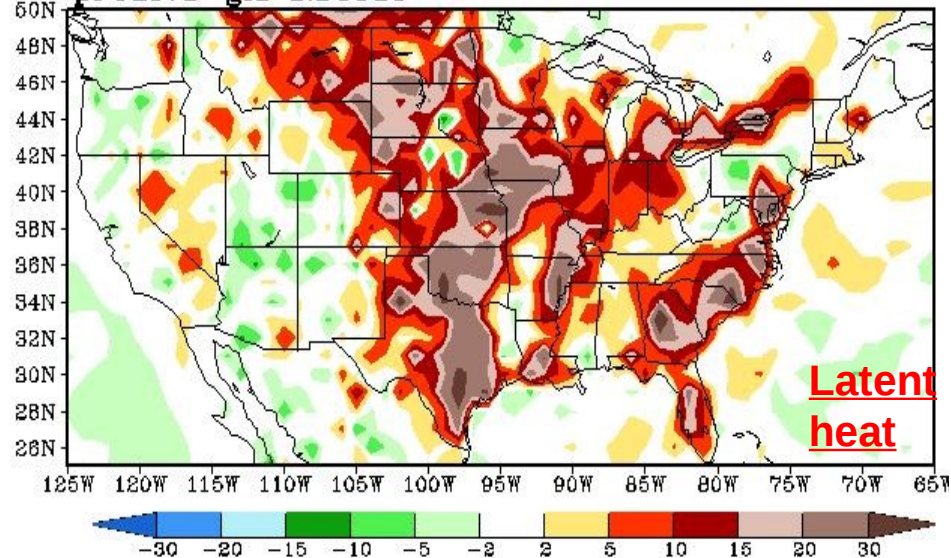
pr4devb-gfs -0.210517



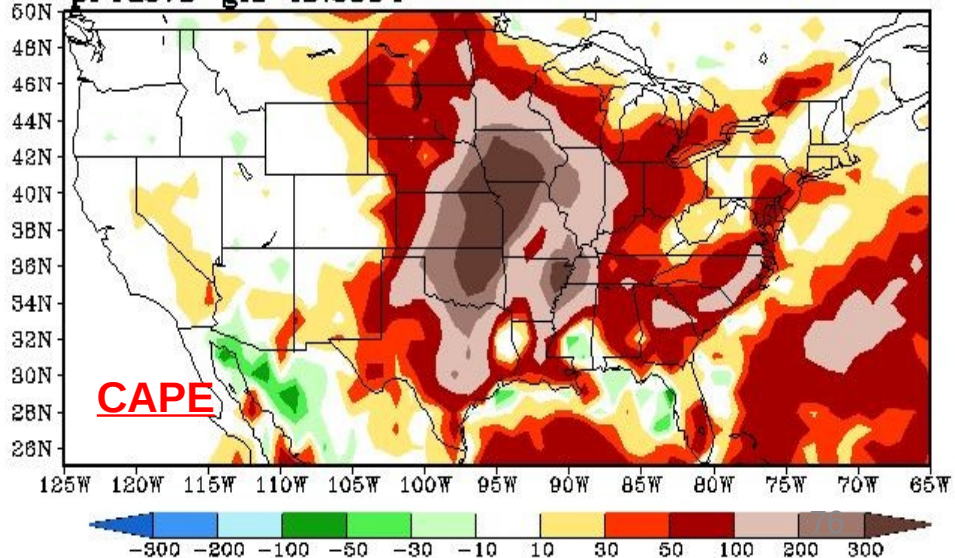
pr4devb-gfs 0.276132

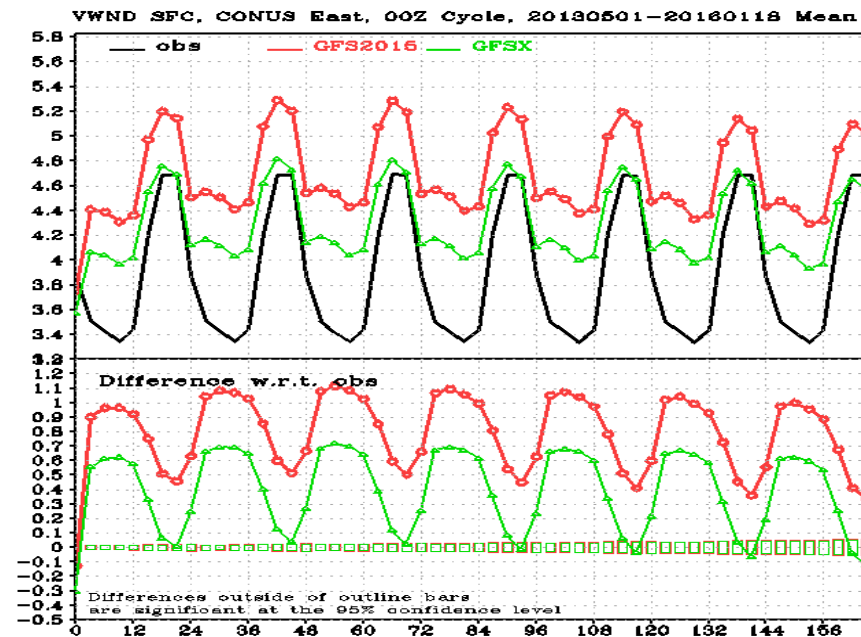
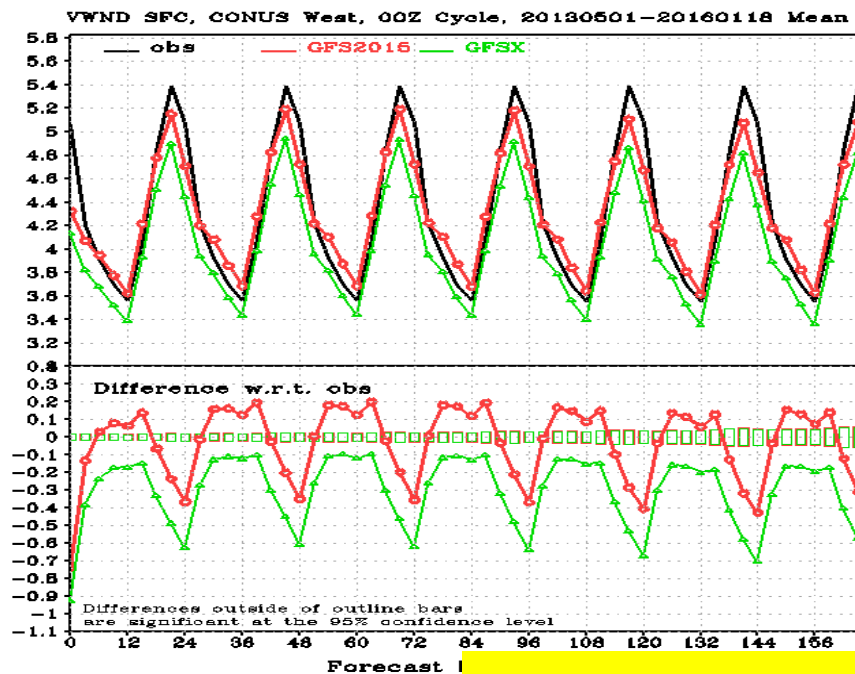


pr4devb-gfs 3.51636

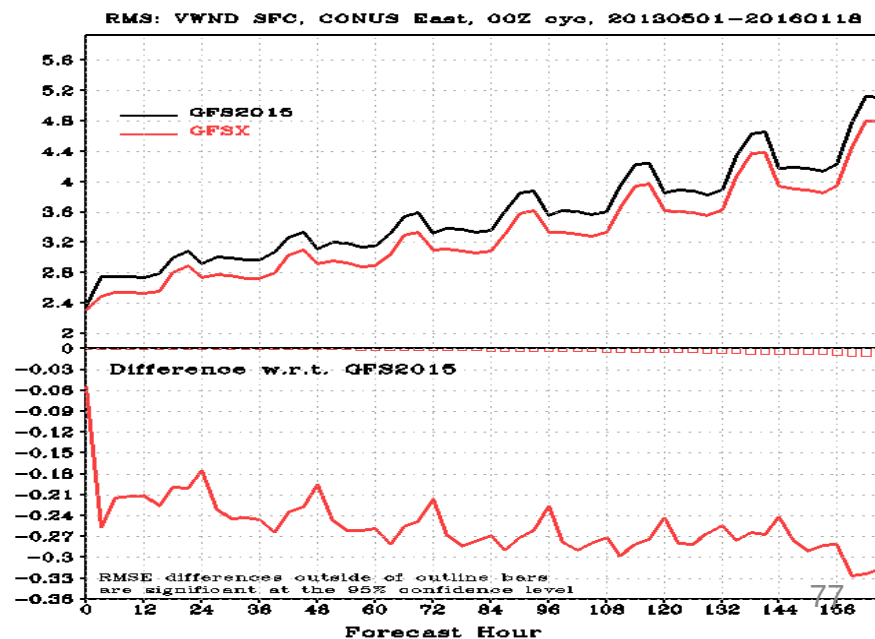
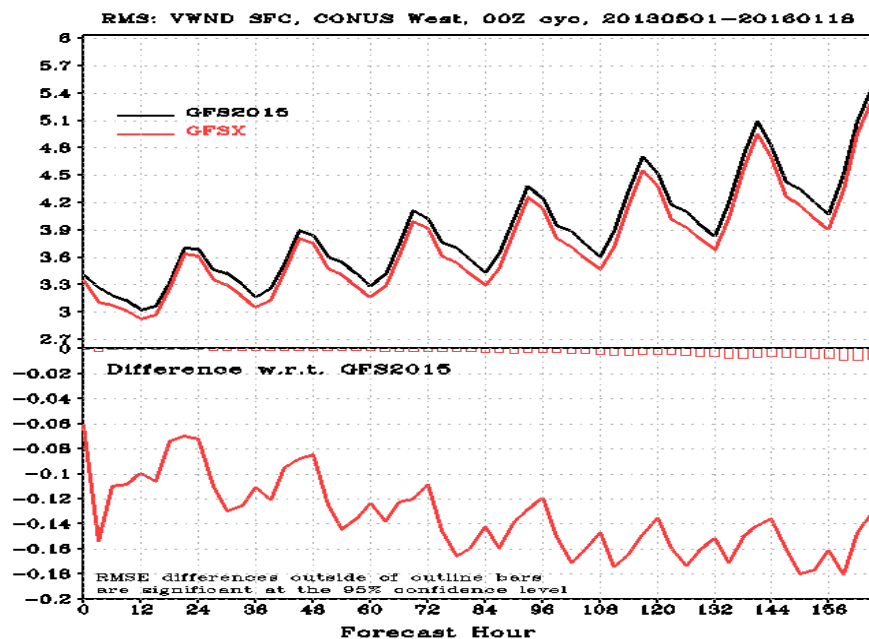


pr4devb-gfs 45.0094





## Surface wind, CONUS West and East, 00Z Cycle



# Preliminary assessment of impact of LSM changes

- 2m T bias is worse over the Northern Plains and Northeast, Better over southern plains and southeast
- RMS error improved over northern and southern plains, Southeast and Alaska, worse over northwest
- 10 m winds decreased, RMS error improved
- **The land surface parameter refinements have significantly reduced the warm/dry biases in the summer**
- **The change has little impact in the winter. However there are some degradations in the spring/fall. Also it is worst in 00Z (sunset). Some of them will be addressed in the next GFS physics implementation.**

# CPC Evaluation of GFSX

## - D+8 & Week 2; - Stratosphere

*Craig Long & Jae-Kyung Schemm*

- 500 hPa height and 850 hPa temperature AC scores and RMS error were compared for NH extra-tropics and the PNA sector for period Jun 1, 2013 – Nov 30, 2015.
- The skill comparisons show **no significant changes** in forecast performance at all leads to 15 days over the operational GFS during the test period except **slight degradation** at longer leads during boreal summer season over the NH and PNA sector.
- There is **no negative** impact in D+8 and Week 2 forecasts from this upgrade.
- Comparisons of GFSX analyses with MLS show GFSX temps to be about 1 deg colder from 200 to 10 mb. GFSX then become warmer between 10 and 1mb by as much as 4-6 degrees,
- Comparison of GFSX f120 with Anl show that f120 is 5-10 deg warm in winter hemisphere temp gradient latitudes above 10mb and about 5 deg cooler in summer hemisphere above 10mb.

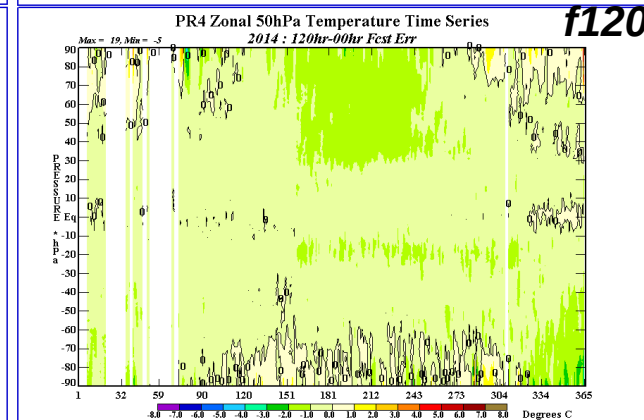
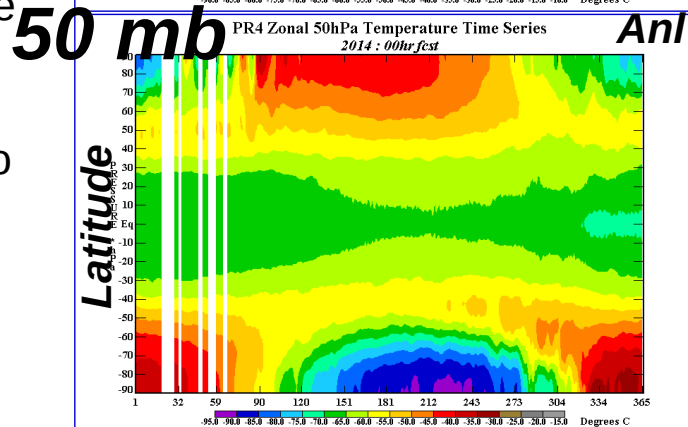
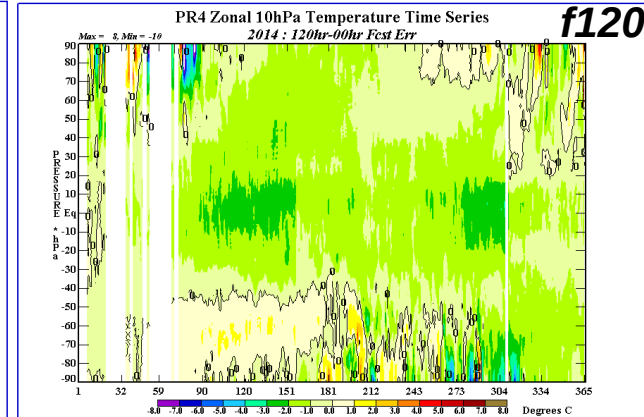
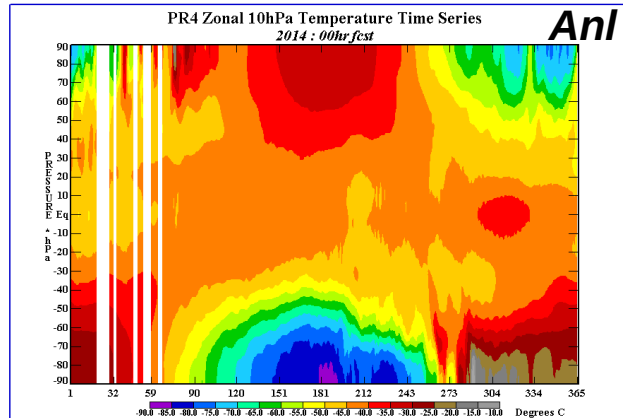
# GFSX Temperature Analysis and 120hr Forecast Err : 2014

## 10 mb

-Temperature analyses and forecasts in stratosphere are quite good in the lower stratosphere at all latitudes and seasons.

-Based upon comparisons with MLS temperatures (see slide 4-8)

-But forecast errors begin to increase in middle stratosphere and become seasonally dependent.



Day of Year

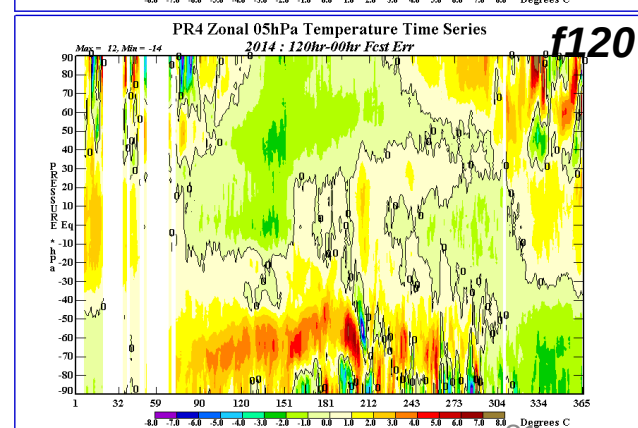
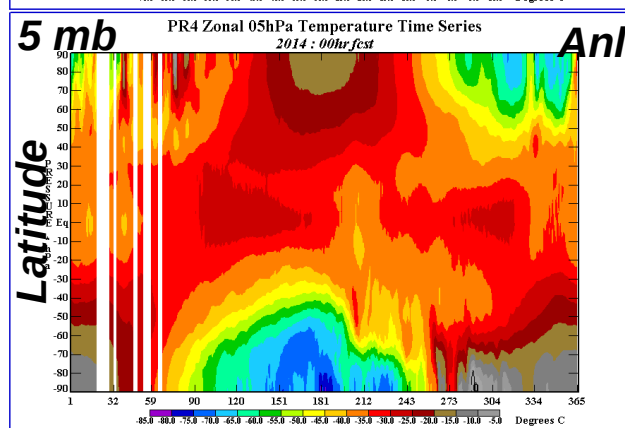
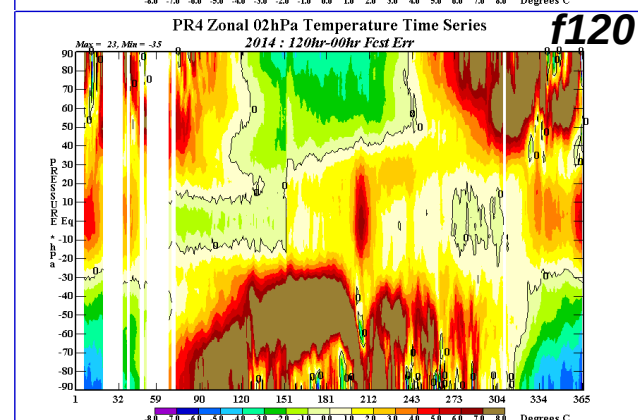
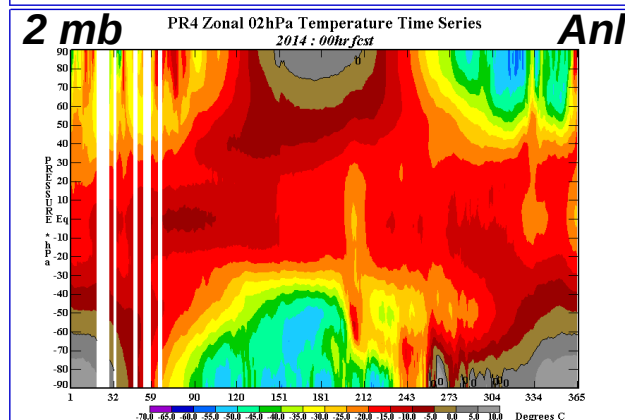
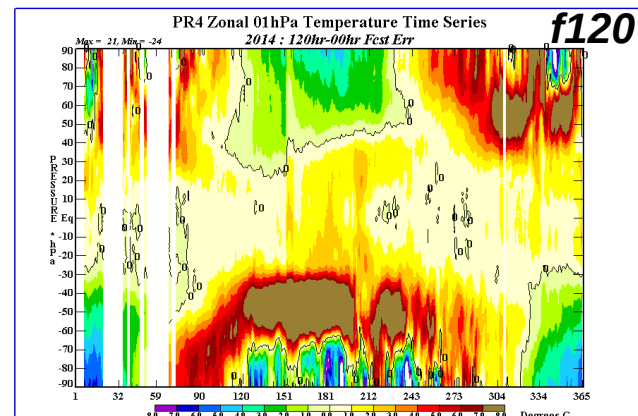
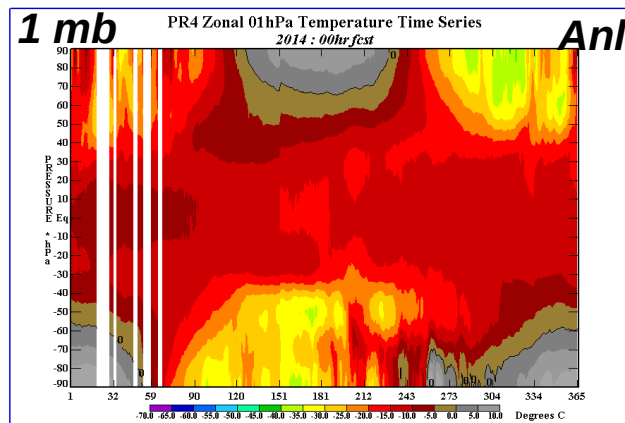
Craig Long, CPC

# GFSX Temperature Analysis and 120hr Forecast Err : 2014

-In upper stratosphere forecast errors are seasonal in each hemisphere's extratropics being greatest + in winter months and greatest – errors in summer months. This means that the gradient across the polar vortex is decreased with fcst time. And summertime fcst temperatures are too cold by 5-10 degrees.

-The decrease in temperature gradient will affect zonal wind speed and PV barrier strength.

Craig Long, CPC



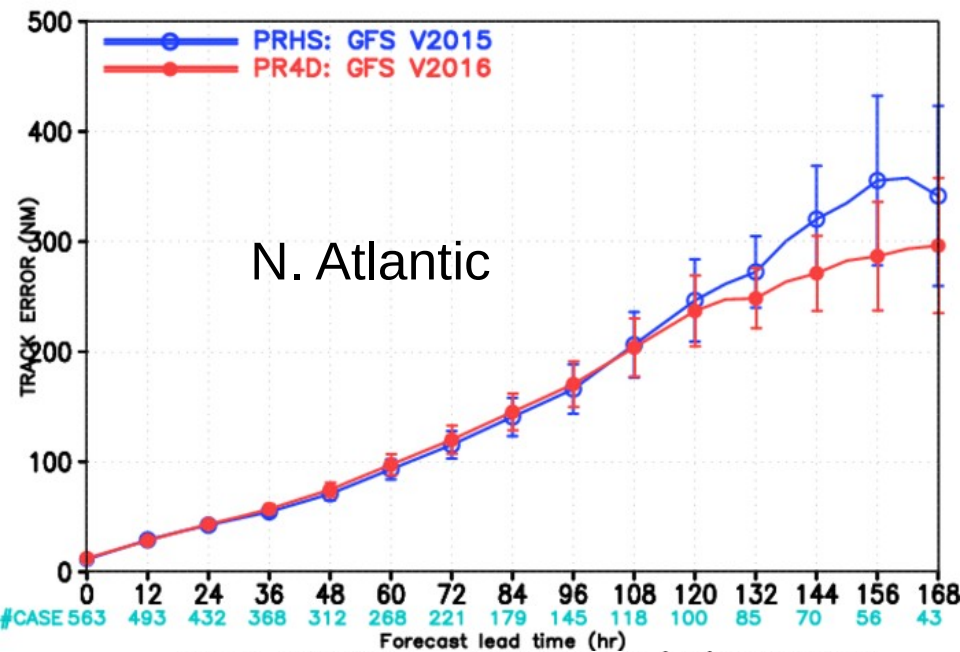
Day of Year

# Overall Evaluation - Stratosphere

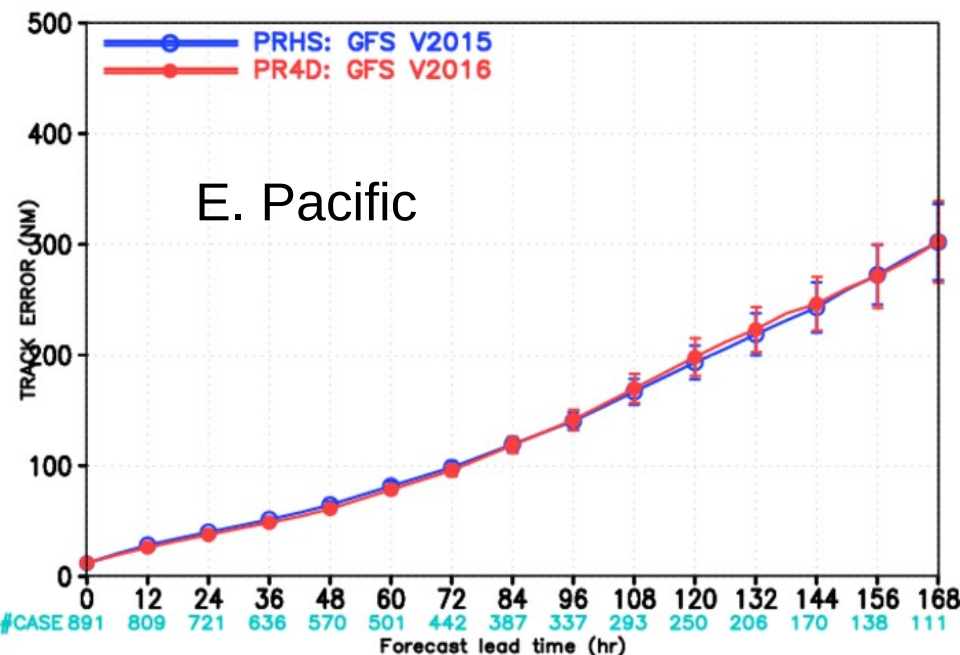
- **Recommendations:**

- Not a show stopper since there is not adverse effects to the troposphere, but large temperature forecast errors need to be examined for a cause.
- These results hopefully will improve when the GFS model top is lifted and more levels are added to the upper stratosphere/lower mesosphere (USLM).
- Currently the top AMSU channel 14 is not assimilated because there are not enough model levels in the USLM for the forward model to generate a good guess.
- Adding more levels will allow the usage of AMSU channel 14 (unbias corrected) and should improve the temperature analysis in the USLM.

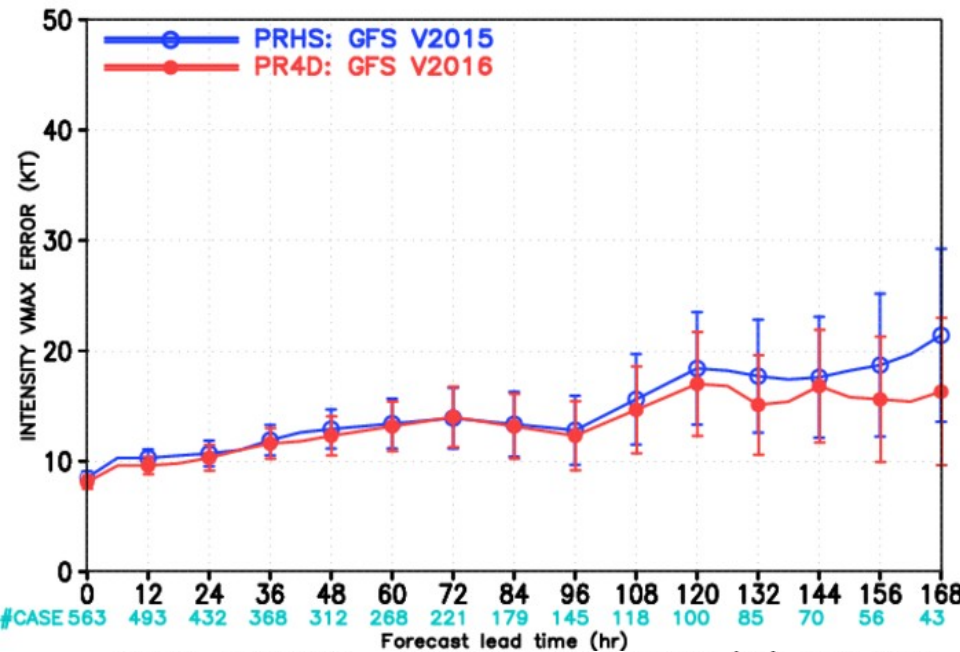
MODEL FORECAST – TRACK ERROR (NM) STATISTICS  
GFS PRHS/PR4D Atlantic 2012–2015



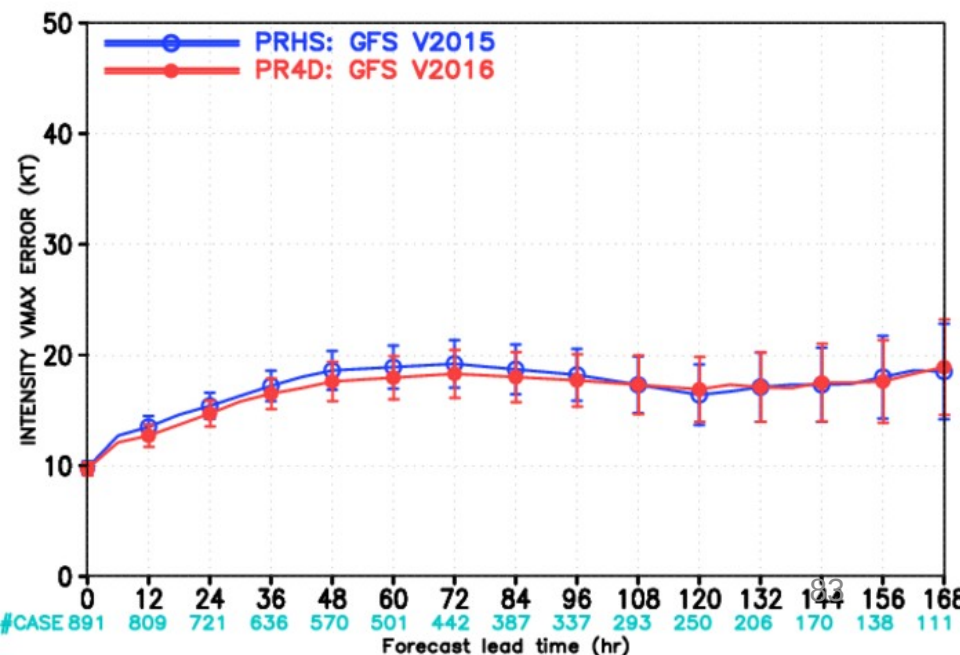
MODEL FORECAST – TRACK ERROR (NM) STATISTICS  
GFS PRHS/PR4D East Pacific 2012–2015



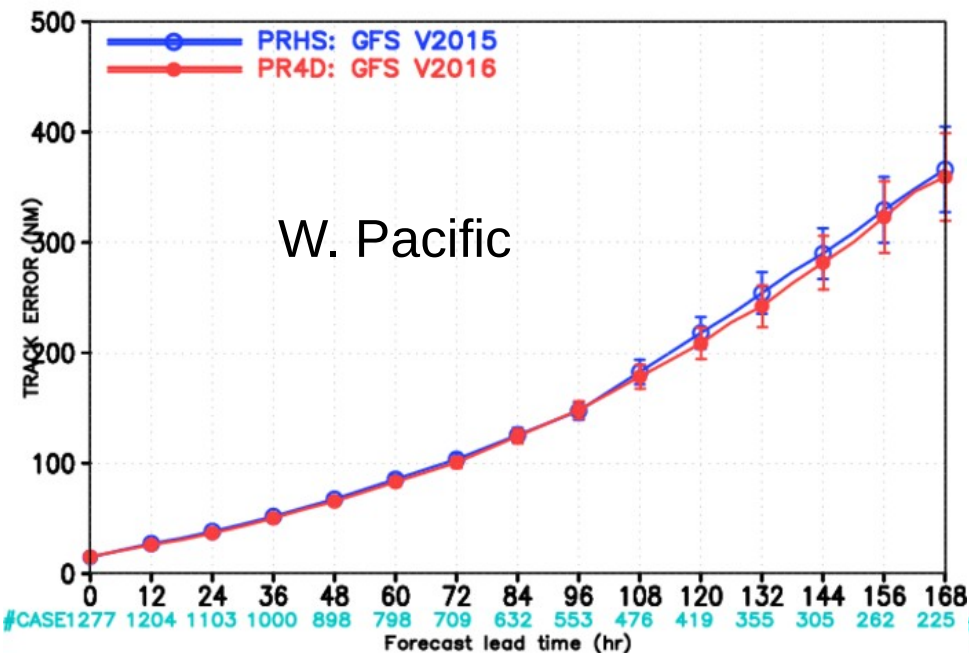
MODEL FORECAST – INTENSITY VMAX ERROR (KT) STATISTICS  
GFS PRHS/PR4D Atlantic 2012–2015



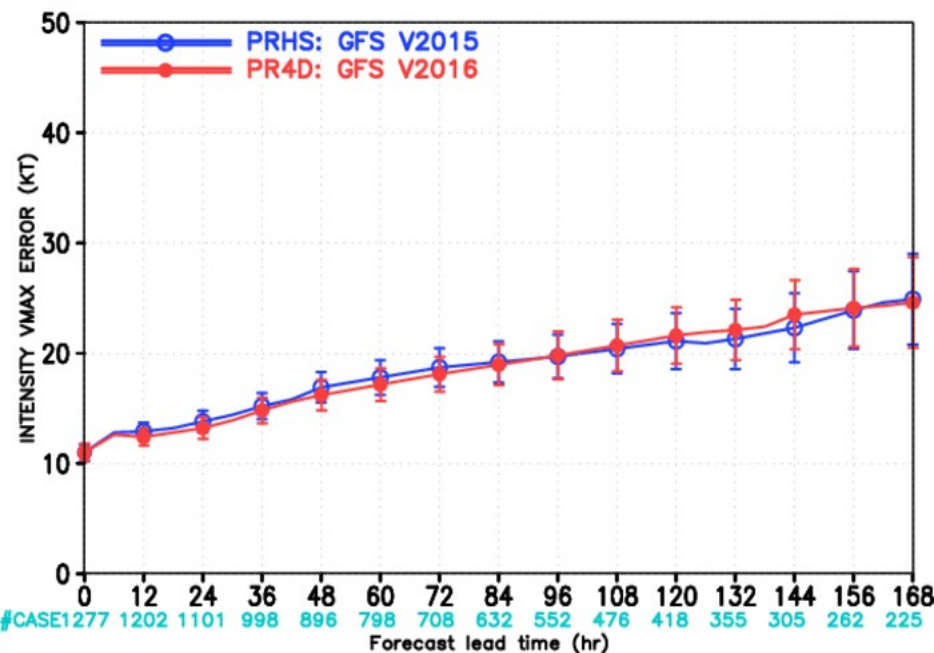
MODEL FORECAST – INTENSITY VMAX ERROR (KT) STATISTICS  
GFS PRHS/PR4D East Pacific 2012–2015



MODEL FORECAST – TRACK ERROR (NM) STATISTICS  
GFS PRHS/PR4D West Pacific 2012–2015



MODEL FORECAST – INTENSITY VMAX ERROR (KT) STATISTICS  
GFS PRHS/PR4D West Pacific 2012–2015



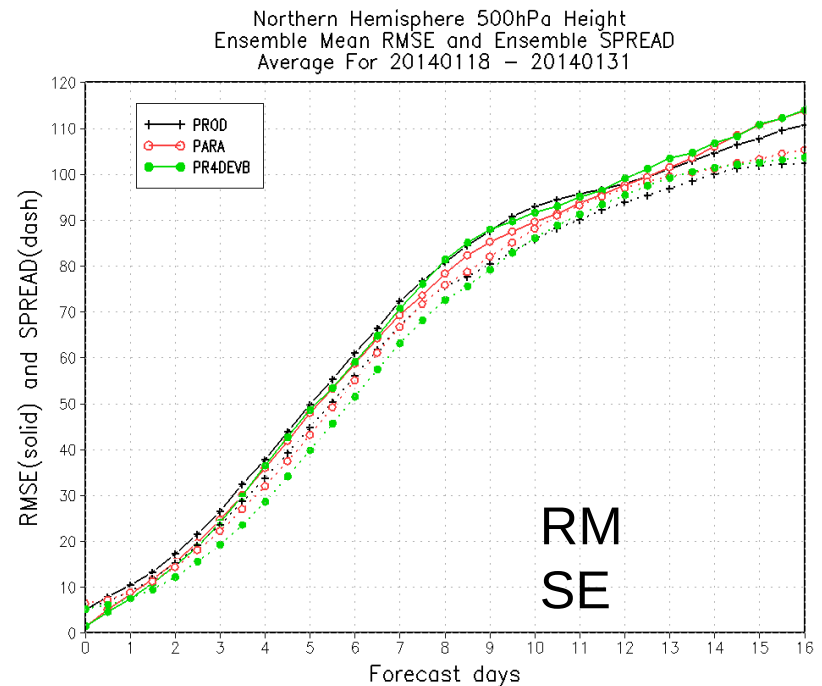
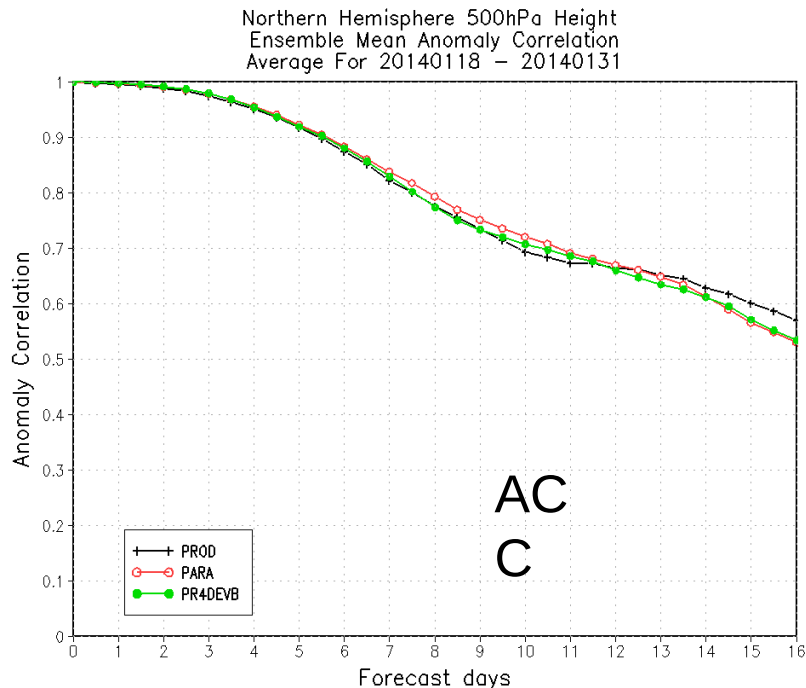
# Mode Verification: GFS vs. GFSX

- Jet Streams: Overall models forecast jets well but present possible systematic biases according to MODE & GFSX generally looks “better” and closer to the ECMWF
- QPF: GFSX has higher MMI (Median of Maximum Interest) values for all forecast hours except at 60-h where it is lower than GFS and statistically significant; GFSX generally forecasts more objects than GFS and observations
- Total winds at 250mb: GFSX did seem a little bit better than the operational GFS based on the MODE statistics. Will look at meridional winds (which already show bigger differences between the GFS and GFSX) and then zonal winds.

# Blizzard of January 2016

- High predictability of the 22–24 January 2016 blizzard that affected the East Coast: Medium-range models had a signal for a significant low along the East Coast about a week in advance of the storm
- Forecasts for the Mid-Atlantic were good. GFS, GFSX, and EC shifted the northern extent of the precipitation shield southward as the event neared, which caused uncertainty in the NYC area

# **DOWNSTREAM MODEL EVALUATION: GEFS & HWRF**



GEFSv11 with different initial  
analysis/perturbation

PROD (black) – GEFSv10 – older production

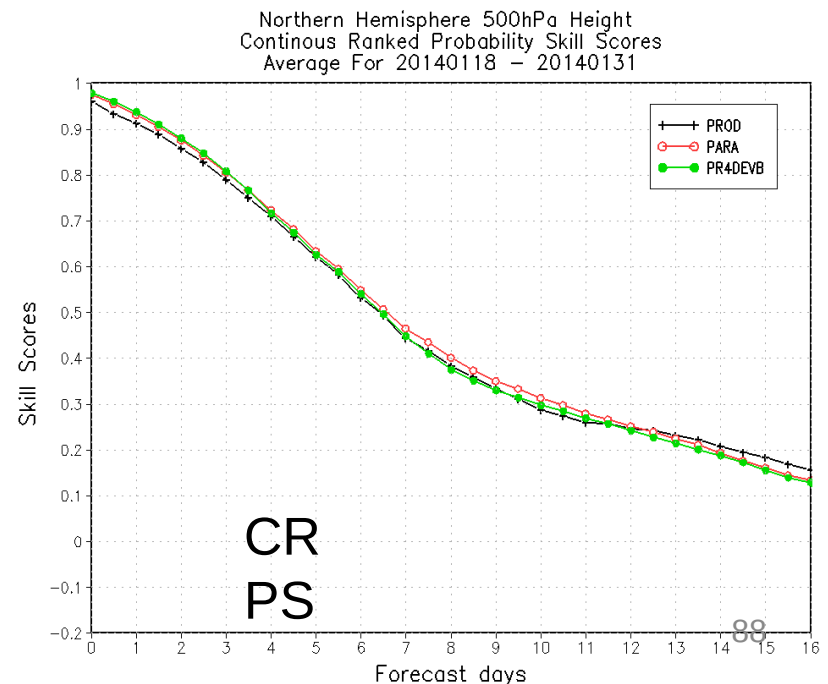
PARA (red) – GEFSv11 operation

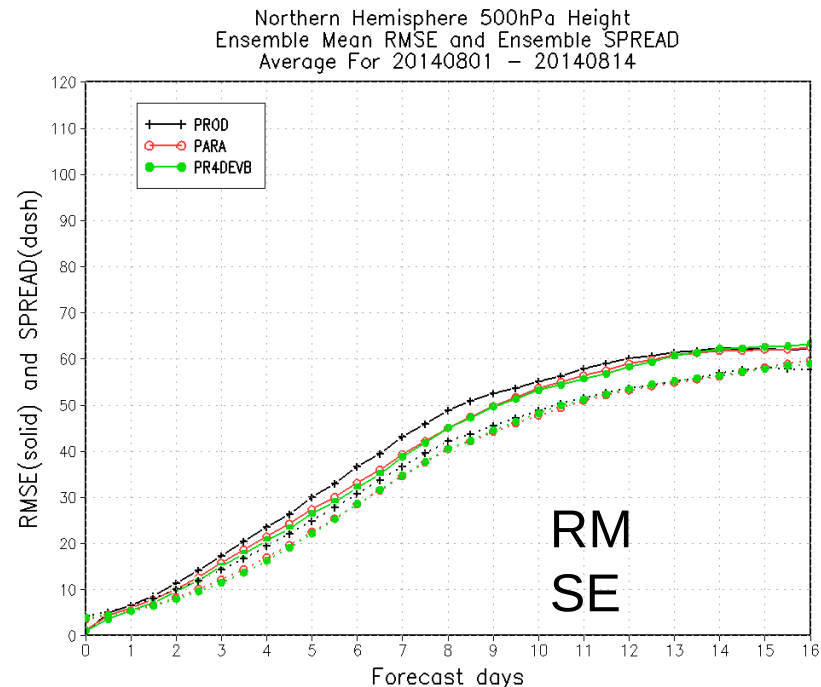
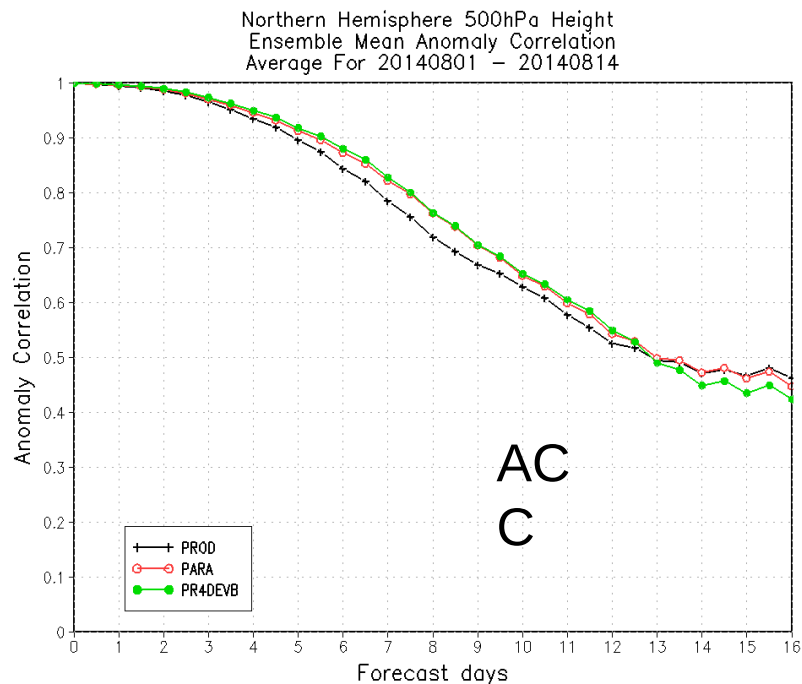
PR4DEVB (green) – Testing

2014 Winter

Good for short forecast (days 1-3)

Slightly degradation (days 5-10)





GEFSv11 with different initial  
analysis/perturbation

PROD (black) – GEFSv10 – older production

PARA (red) – GEFSv11 operation

PR4DEVB (green) – Testing

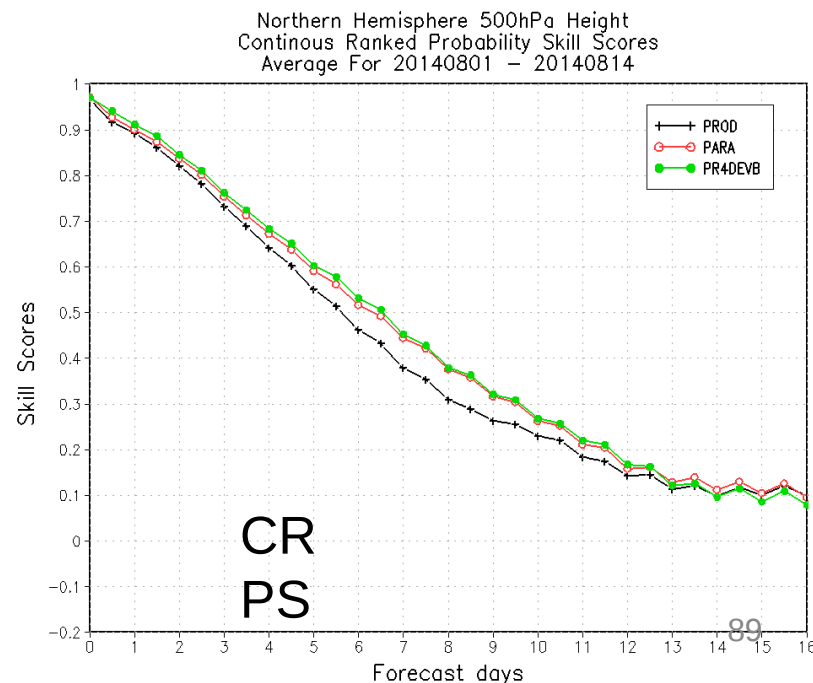
2014 Summer

Good for all lead time (out to day 12)

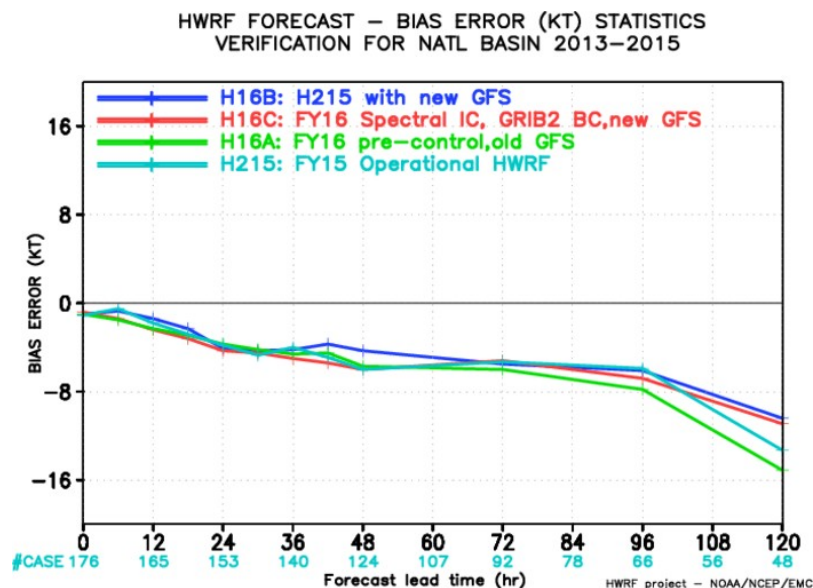
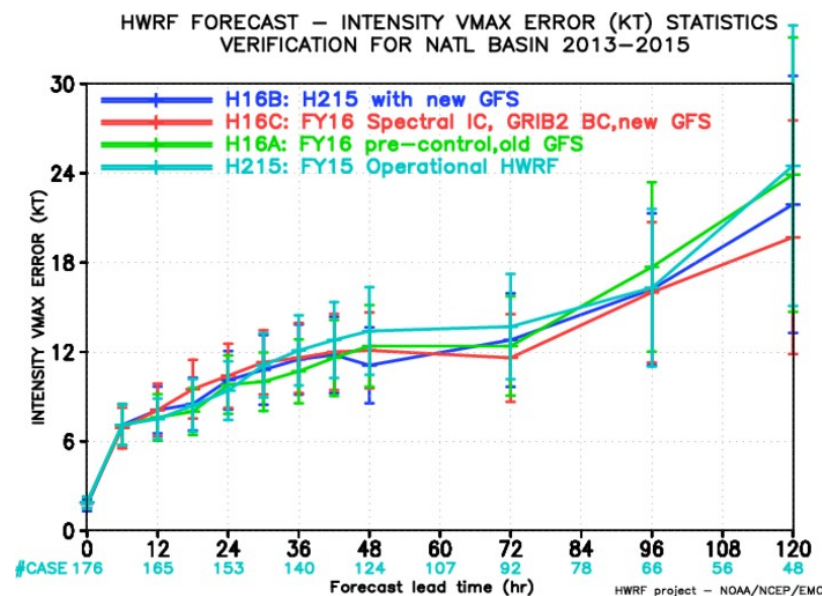
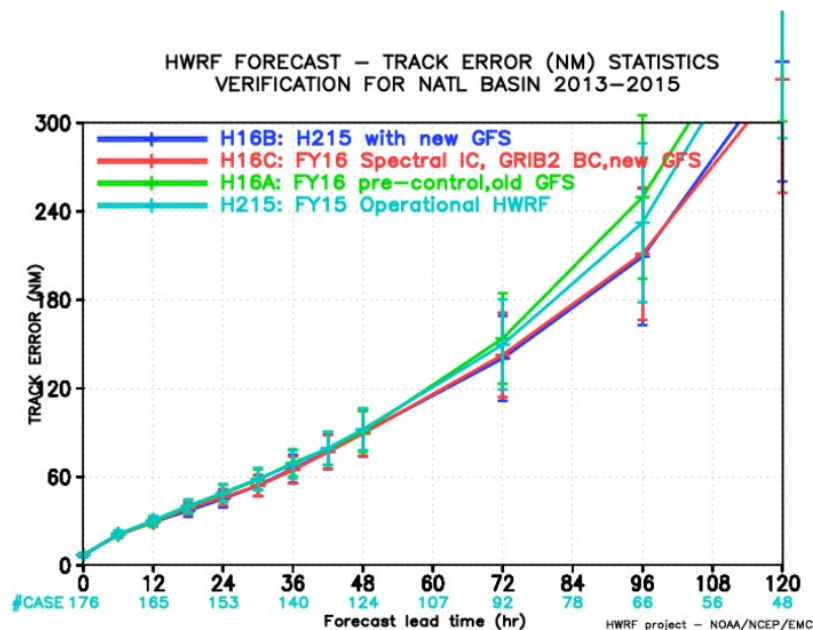
Overall:

initial spread is smaller than before

Growth of spread is similar to current



# 2015 HWRF with new GFS, ATL



H16A, FY16 HWRF, Current GFS

H16B, FY15 HWRF, new GFS

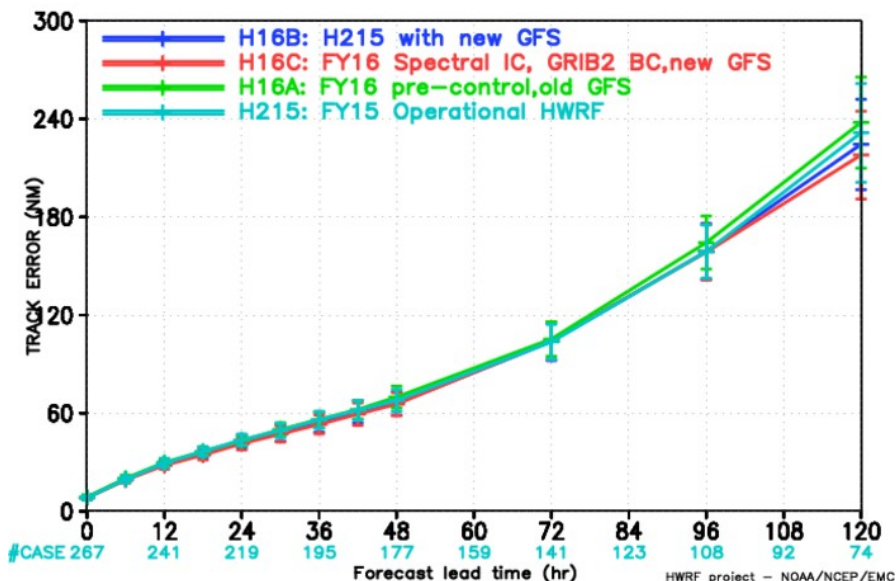
H16C, FY16 HWRF, new GFS

H215, FY15 HWRF, current GFS

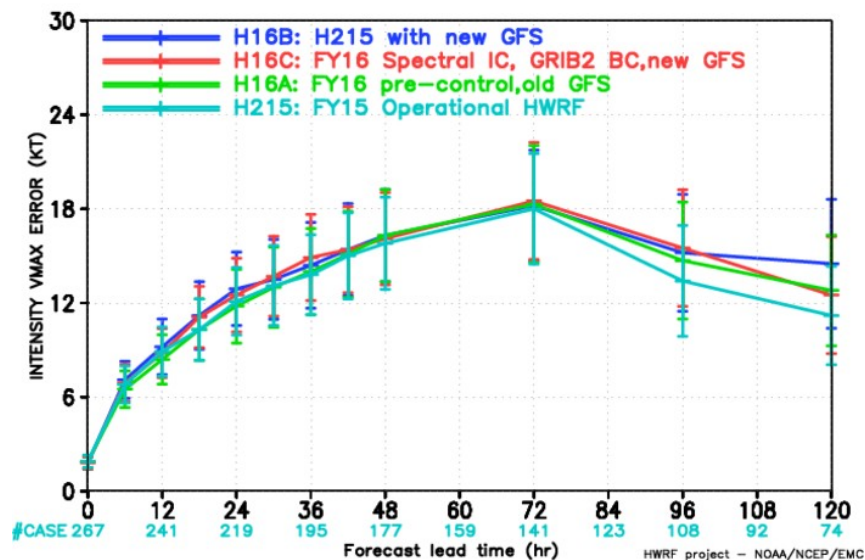
New GFS (blue/red) shows improved track and intensity forecasts in the N. Atlantic

# 2015 HWRF with new GFS, EPAC

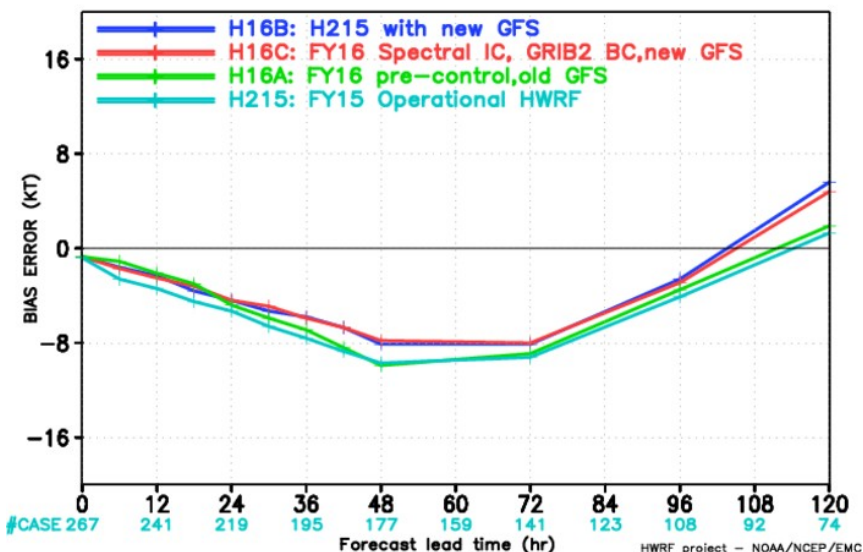
HWRF FORECAST – TRACK ERROR (NM) STATISTICS  
VERIFICATION FOR EPAC BASIN 2013–2015



HWRF FORECAST – INTENSITY VMAX ERROR (KT) STATISTICS  
VERIFICATION FOR EPAC BASIN 2013–2015



HWRF FORECAST – BIAS ERROR (KT) STATISTICS  
VERIFICATION FOR EPAC BASIN 2013–2015



H16A, FY16 HWRF, Current GFS

H16B, FY15 HWRF, new GFS

H16C, FY16 HWRF, new GFS

H215, FY15 HWRF, current GFS

New GFS (blue/red) shows neutral impact on track and intensity forecasts in the E. Pacific

# Extratropical Tracks

- For the winter, Nov.1 2013 - April 30 2014, position error is smaller in GFSX than in GFS control seven out of ten forecast hours (0 - 120hr in 12hr interval).
- For the summer, April 1 2015 - Oct. 31 2015, GFSX errors are always smaller than GFS control's.

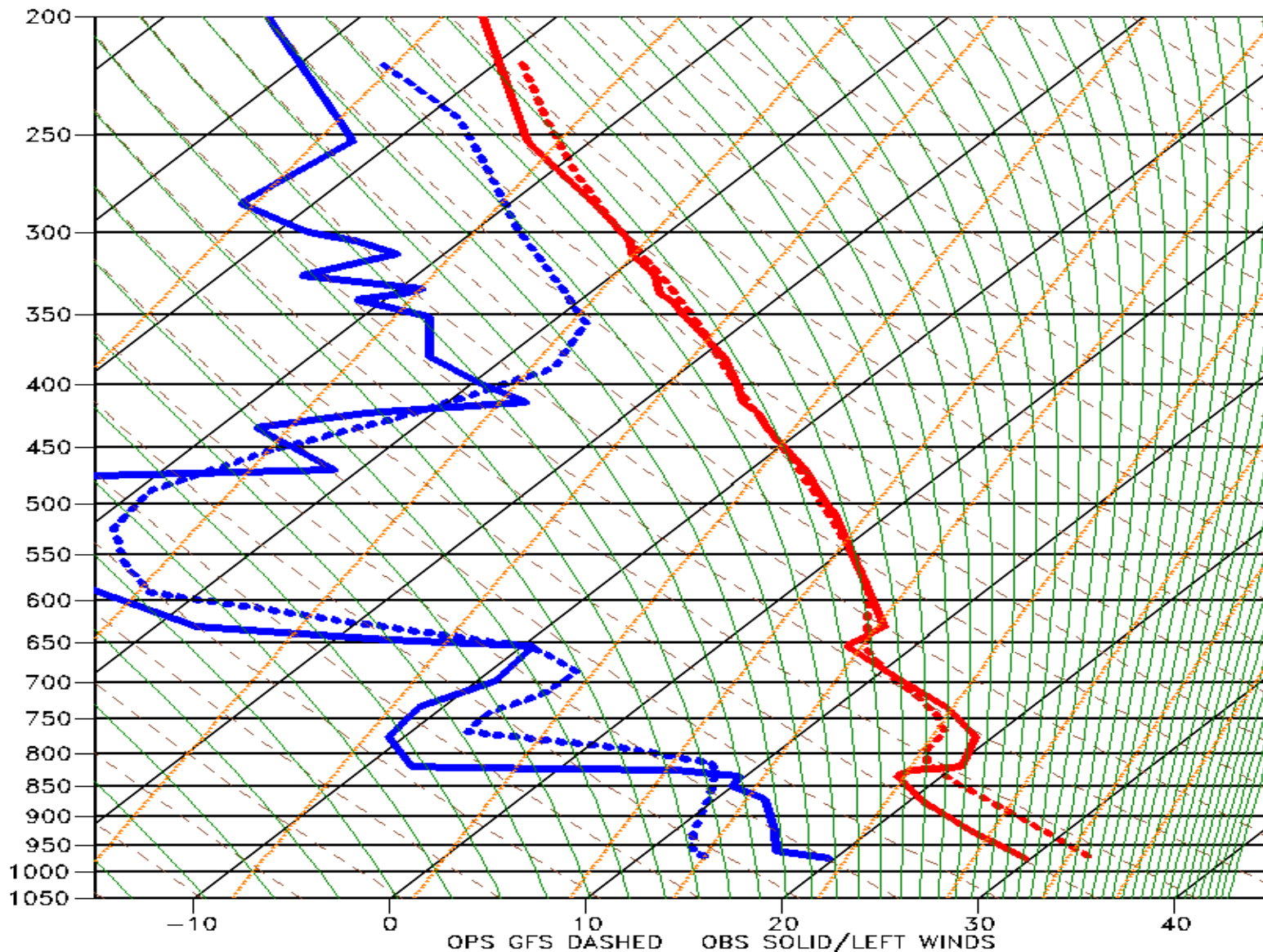
# Sounding and Height Case Studies

- For sounding case studies, GFSX looked better than operational GFS for North Platte, NE, looked the same for Aberdeen, SD, and looked much better near the surface for Omaha, NE for Aug. 16, showing reduction in warm dry bias
- For the spaghetti plots of a height contour, of 5 cases requested by WPC, GFSX did better for 3 cases, did the same for 1 case, and did worse for 1 case. The case the GFSX did worse on was the 180-h forecast from 00Z 12/7/14 valid on 12Z 12/14/14.

# 12h GFS FCST vs OBS for Omaha, NE

150816/0000 72558 OAX CAPV: 25 CINV: -228 LCLP: 842  
150816/0000 725580 CAPV: 0 CINV: 0 LCLP: 731

GFS

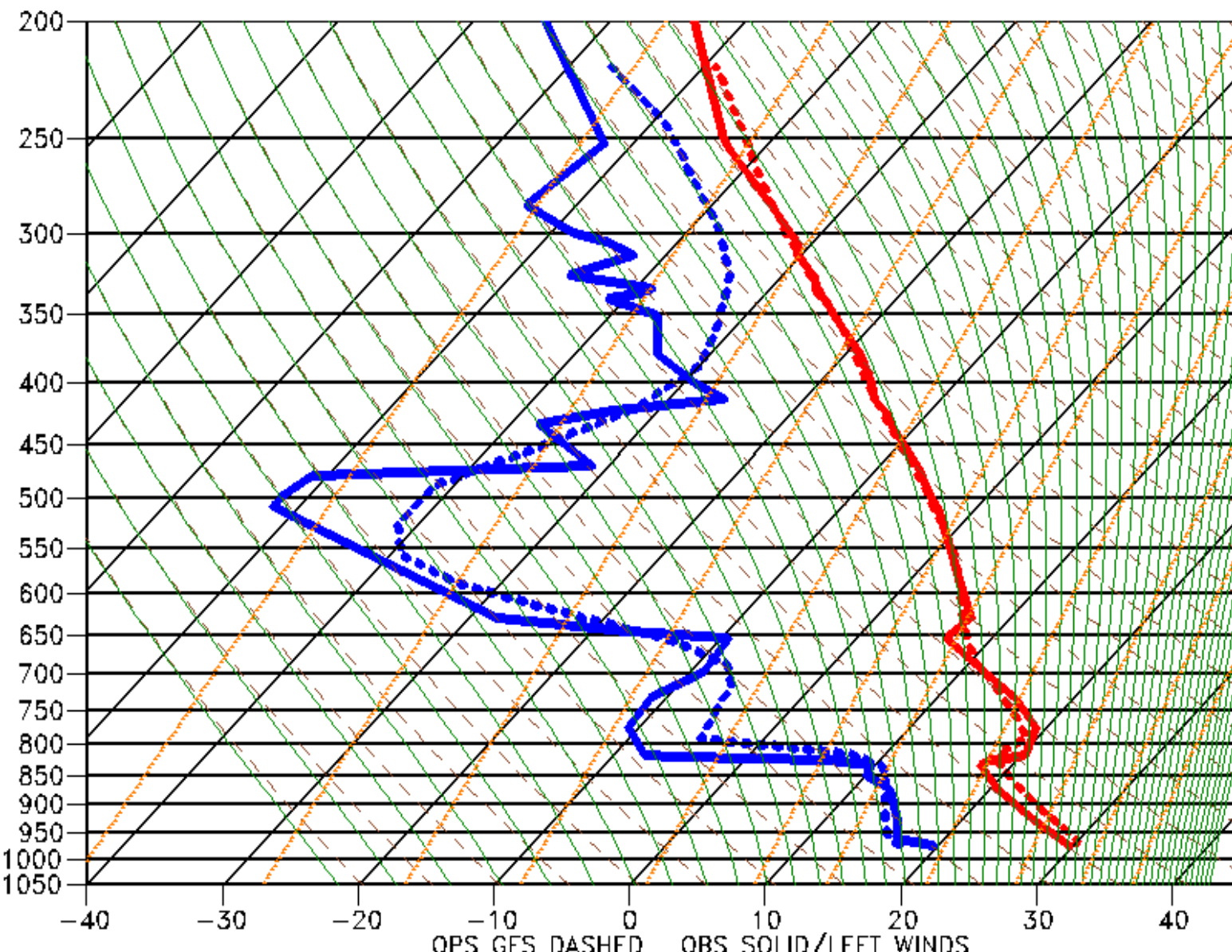


T. Dorian<sup>94</sup>

150816/0000 72558 OAX  
150816/0000 725580

CAPV: 25 CINV: -228 LCLP: 842  
CAPV: 0 CINV: 0 LCLP: 804

# GFSX



T. Dorian<sup>95</sup>

# Super Typhoon Atsani Findings

- GFS too far to the north and east, then too far to the east, followed by too far to the north (except for 204-h forecast, GFS too far south)
- GFSX started off with good position for Atsani, then was too far south and east, then slightly too far north, then too far south for 204-h forecast
- In general, the GFSX was closer to analysis

<i>Forecast Lead Time</i>	<i>GFS</i>	<i>GFSX</i>
<i>108</i>		✓
<i>120</i>		✓
<i>132</i>		✓
<i>144</i>	✓	✓
<i>156</i>		✓
<i>168</i>	✓	
<i>180</i>		✓
<i>192</i>		✓
<i>204</i>	✓	

# Compute / runtime changes

## GFS/GDAS Forecasts for hourly output through 120 h

<i><b>Job Step</b></i>	<i><b>Current phase 1 production, (slow bacio)</b></i>		<i><b>Proposed phase 2 production, (fast bacio)</b></i>	
	<i><b>Nodes /Tasks</b></i>	<i><b>Runtime (min)</b></i>	<i><b>Nodes /Tasks</b></i>	<i><b>Runtime (min)</b></i>
<i><b>gfs_fcst_high (hourly output for the first 12 hours, then 3 hourly up to 240 hours)</b></i>	<i><b>432/108</b></i>	<i><b>83.0</b></i>	<i><b>390/65</b></i>	<i><b>82.2</b></i>
<i><b>gfs_fcst_high (hourly output for the first 120 hours, then 3 hourly up to 240 hours)</b></i>			<i><b>540/90</b></i>	<i><b>81.2</b></i>
<i><b>gfs_fcst_low (12 hourly output, from 240 to 384 hours)</b></i>	<i><b>216/27</b></i>	<i><b>15.0</b></i>	<i><b>216/18</b></i>	<i><b>14.5</b></i>
<i><b>gdas_fcst_high (hourly output up to 9 hours)</b></i>	<i><b>432/108</b></i>	<i><b>10.5</b></i>	<i><b>258/43</b></i>	<i><b>8.5</b></i>

Current operation takes 48\*6GB=288GB for the first 120 hours of forecast. Additional 73\*6GB=438GB disk is required for storing hourly output up to 120 hours.

# ***Evaluation plans for Q3FY16 GDAS/GFS***

- Hurricane tracks days 6 and 7 (done) with statistical significance
- ***Data to NHC for assessing forecasts of tropical cyclone genesis and other evaluation***  
--- **Completed**
- EMC producing Gempak files from real time parallel
- MAG evaluation page activated
- Western Region using side by side maps for N. America, N. Pac, WPC also using Gempak files
- Files for hourly output data developed (evaluated by CPC and NWC)
- Data from real time parallel on paraNOMADS (NCO) (problem with availability time)
- Synoptic maps and daily precip verification for real time parallel available on EMC web pages
- g2o (near surface verification) for all 4 cycles (done)
- Precip, jet stream, CAPE MODE verification
- Worked with Western, Central, Alaska, Southern, Eastern and Pacific Regions ---  
**Completed**
- Worked with WPC, NHC, NCO, CPC, SPC, AWC, OPC, SWPC, MDL, NWS, Academia and private industry --- **Completed**

Continuity objective score-needs long term development

# Evaluation plans for Q3FY16 GDAS/GFS

- GFS Soundings—available on case by case basis, real-time web page for selected cities
- Real time plots of near surface variables at representative stations –available for GFS, GEFS  
[http://www.emc.ncep.noaa.gov/gc\\_wmb/parthab/Plume\\_test/GFSx/EMCGEFSplumes.html](http://www.emc.ncep.noaa.gov/gc_wmb/parthab/Plume_test/GFSx/EMCGEFSplumes.html)
- Retrospectives—Standard verification page—against own analyses, GFS2015 vs. GFS2016  
<http://www.emc.ncep.noaa.gov/gmb/wx24fy/vsdb/gfs2016/>
- **Case studies— Hurricane Sandy:** <http://www.emc.ncep.noaa.gov/gmb/wd20rt/vsdb/pr4devbs12/>
- **Case studies from Centers and Regions**  
<http://www.emc.ncep.noaa.gov/gmb/noor/4dGFS/docs/MEGGFSxCaseStudies.pptx>  
<http://www.emc.ncep.noaa.gov/gmb/noor/4dGFS/docs/RetroRunsWRcases.pptx>  
<http://www.emc.ncep.noaa.gov/gmb/noor/4dGFS/docs/26Mar2015CentralRegion.pptx>  
<http://www.emc.ncep.noaa.gov/gmb/noor/4dGFS/docs/CentralRegionJune45.pptx>  
<http://www.emc.ncep.noaa.gov/gmb/noor/4dGFS/docs/CentralRegionCaseJuly6.pptx>  
<http://www.emc.ncep.noaa.gov/gmb/noor/4dGFS/docs/centralnov17.pptx>  
<http://www.emc.ncep.noaa.gov/gmb/noor/4dGFS/docs/joaquinsum.pptx>  
<http://www.emc.ncep.noaa.gov/gmb/noor/4dGFS/docs/WPCstudies226.pptx>  
<http://www.emc.ncep.noaa.gov/gmb/noor/4dGFS/docs/GFSXEvaluations.pptx>
- **EMC could plot basic maps and place online, could make data for cases available**
- **Examine time-means, systematic errors**
- **Synoptic assessment of PBL structure and other fields by MEG; Revisit MEG cases**  
<http://www.emc.ncep.noaa.gov/gmb/noor/4dGFS/docs/extracasesMEGa.pptx>

--keep websites comparing GFS and GFSX up  
until implementation

--start to plan next implementation procedure March 18

real time—experimental GFS in AWIPS

retrospective—generate synoptic maps dprog/dt  
(Western Region program?)

zoomable? Differences, errors?

precipitation verification maps (Fanglin Yang)

enable forecasters (SOOs?) to do case studies

# ***Future work***

***Reduce “socialist rain”***

***Increase amount of moderate rain***

***Cold bias over snow***

***Improve upper stratospheric forecasts***

***Reduce near surface biases, improve  
diurnal cycle***

***Improve boundary layer***

***Reduce dry bias in southeast US***